



# MITOCHONDRIAL PHYLOGENY AND SYSTEMATICS OF PALEARCTIC EAGLES

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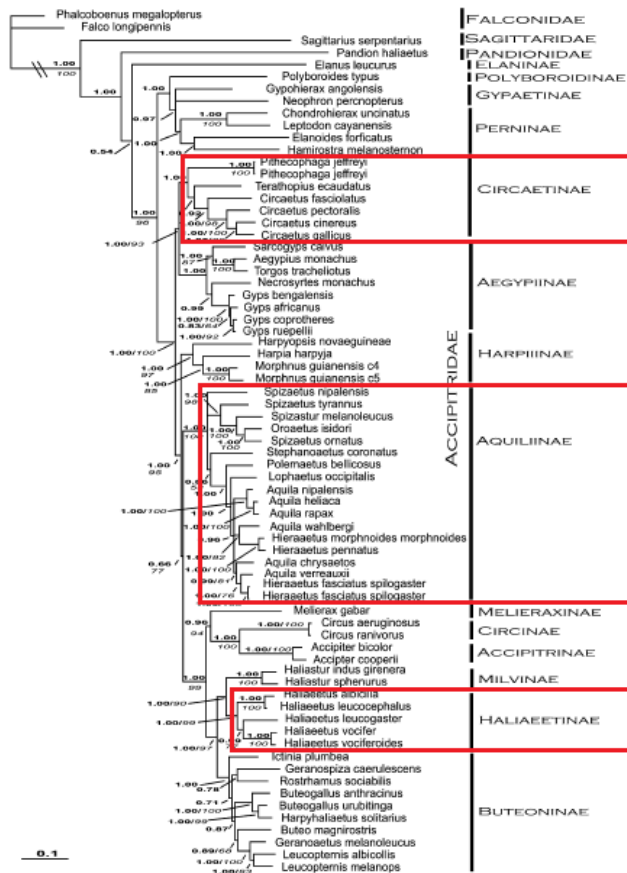
# INTRODUCTION

Eagles are a polyphyletic group of large diurnal raptors (Accipitridae). 3 subfamilies in Palearctic:

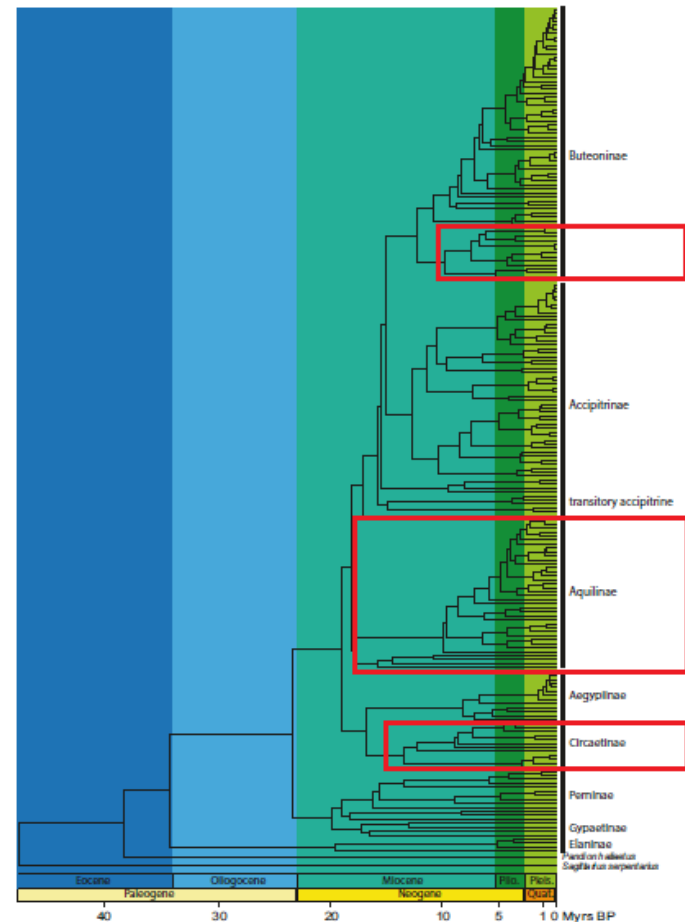
- Aquilinae (true eagles). 4 genera (*Aquila*, *Clanga*, *Hieraetus*, *Nisaetus*)/10 spp.
- Haliaeetinae (fish eagles), sometimes merged with Buteoninae. 1 genus (*Haliaeetus*)/3 spp.
- Circaetinae (snake eagles). 1 genus (*Circaetus*)/1 sp.

Various research on phylogeny over the past 30 years. Phylogenetic position of this group taxa at species level and above based on nuclear and mitochondrial markers is currently clarified. But below?

The goal of our research was to summarize existed genetic data on mitochondrial phylogeny and to compare it with current systematics of Palearctic Eagles



Lerner, Mindell 2005. 3 markers



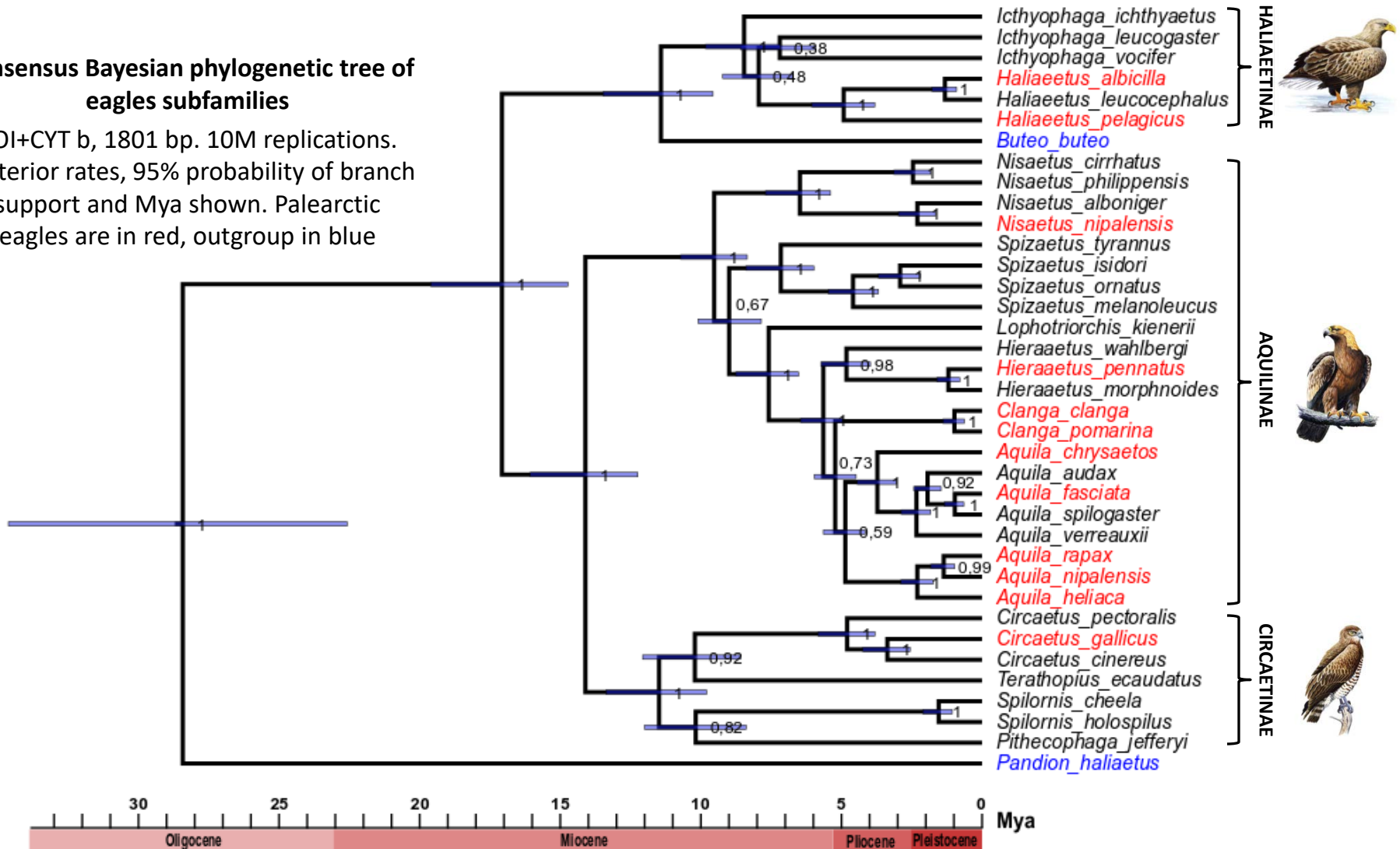
Mindell et al. 2018. 10 markers



# RESULTS & DISCUSSION

## Consensus Bayesian phylogenetic tree of eagles subfamilies

COI+CYT b, 1801 bp. 10M replications.  
Posterior rates, 95% probability of branch support and Mya shown. Palearctic eagles are in red, outgroup in blue



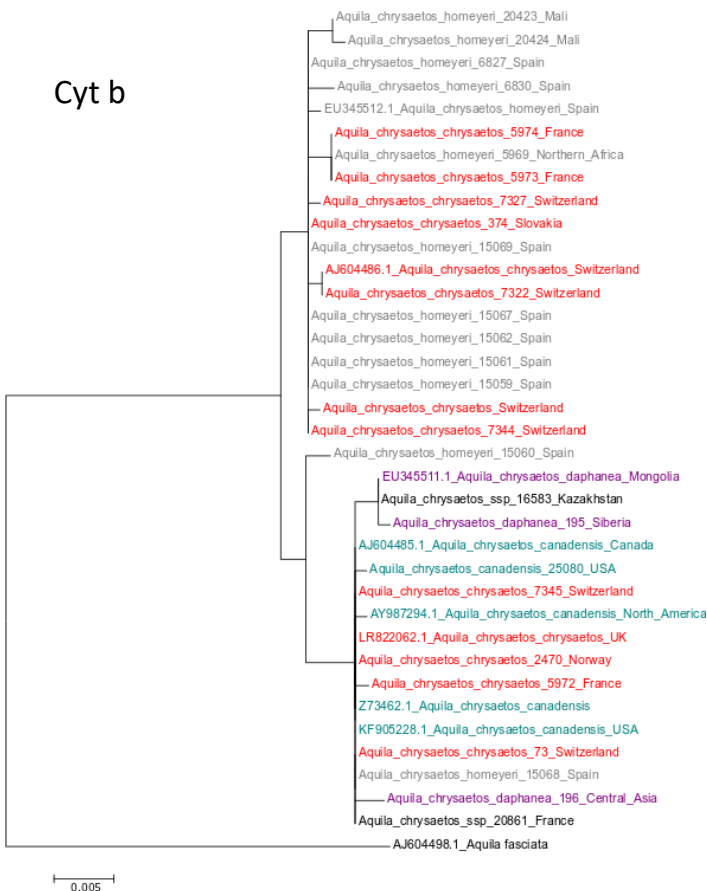
- Topology of the tree matches with previous nuclear and mitochondrial phylogenies
- Three subfamilies of eagles appeared independently in mid-Miocene
- Existing eagle genera were formed in Miocene/Pliocene boundary
- Different groups settled Palearctic realm several times
- Some groups were formed directly in Palearctic: *Clanga spp.*, *Aquila rapax-nipalensis-heliaca*

# RESULTS & DISCUSSION

## *Aquila chrysaetos* Golden Eagle

Species	Golden Eagle	<i>Aquila chrysaetos</i>	(Linnaeus, 1758)	NA, MA, PAL : widespread
ssp		<i>A. c. chrysaetos</i>	(Linnaeus, 1758)	Europe to nc Asia
ssp		<i>A. c. kamtschatica</i>	Severtsov, 1888	ne Asia
ssp		<i>A. c. japonica</i>	Severtsov, 1888	Korean Pen. and Japan
ssp		<i>A. c. daphanea</i>	Severtsov, 1888	c Asia
ssp		<i>A. c. homeyeri</i>	Severtsov, 1888	Iberian Pen., n Africa through the Middle East to Iran and Uzbekistan
ssp		<i>A. c. canadensis</i>	(Linnaeus, 1758)	Alaska, Canada, w USA and wc Mexico

Cyt b



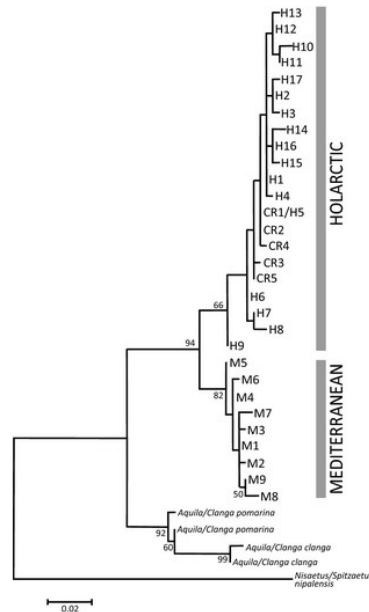
- 6 subspecies
- Cyt b phylogeny (GenBank + our data) reveals two distinct lineages: Mediterranean and all other range
- No genetic differentiation between ssp. except *homeyeri* (possible intergrade with nominate form), K2P = 0.7 – 1.4%
- Only two real ssp., *chrysaetos* (with *homeyeri*) and *canadensis* (with all others)? (Wink, Sauer-Gürth 2004). Not so simple

# RESULTS & DISCUSSION

Research on the control region (D-loop): 283 birds, all ssp.

- Two haplotypes: Mediterranean-Alpine (M) and other Holarctic (H)
- Ssp distribution:

	M	H
<i>chrysaetos</i> (Med., Alps)+ <i>homeyeri</i>	150	24
<i>chrysaetos</i> (N Europe)	0	55
<i>chrysaetos</i> (E Europe)	6	11
<i>daphanea+kamtschatica</i>	0	14
<i>japonica</i>	0	12
<i>canadensis</i>	0	7

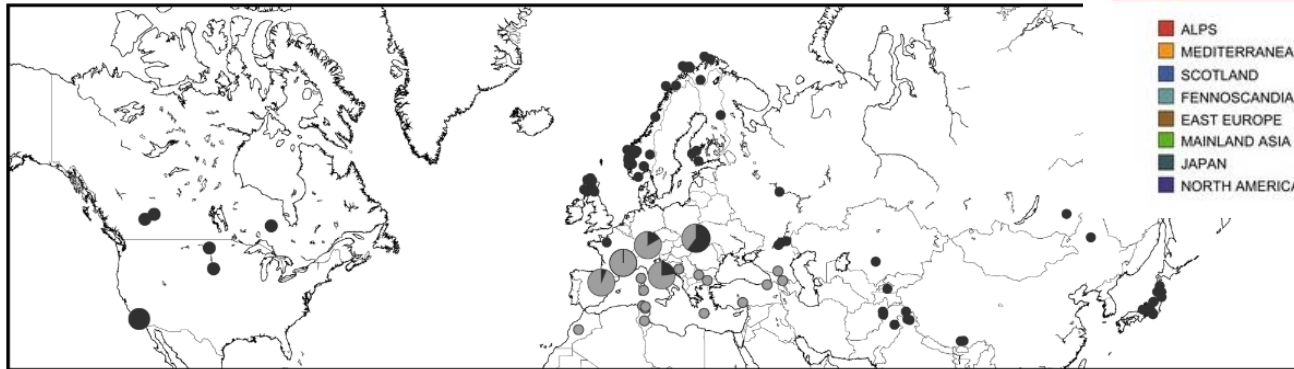
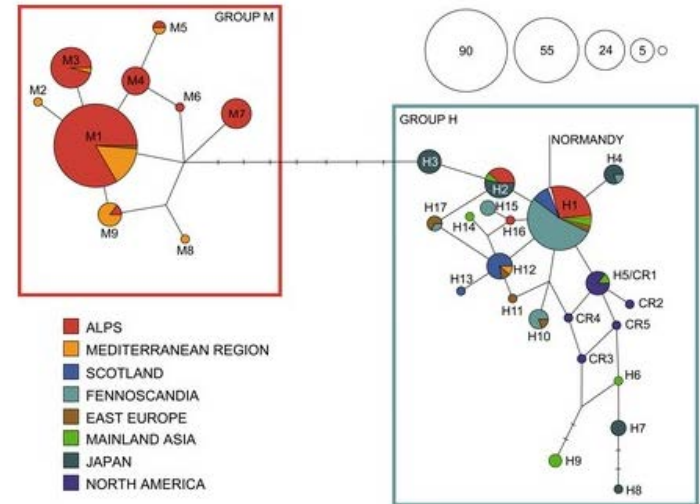


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## Mitochondrial DNA analysis reveals Holarctic homogeneity and a distinct Mediterranean lineage in the Golden eagle (*Aquila chrysaetos*) FREE

Carina Nebel ✉, Anita Gamauf, Elisabeth Haring, Gernot Segelbacher, Alexandre Villers, Frank E. Zachos

*Biological Journal of the Linnean Society*, Volume 116, Issue 2, October 2015, Pages 328–340, <https://doi.org/10.1111/bij.12583>



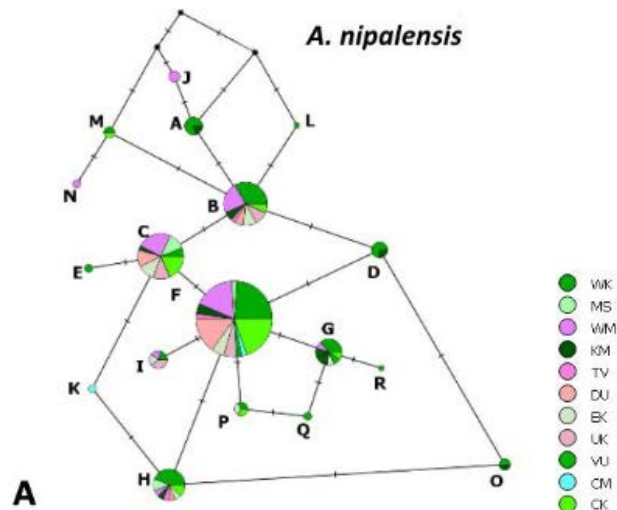
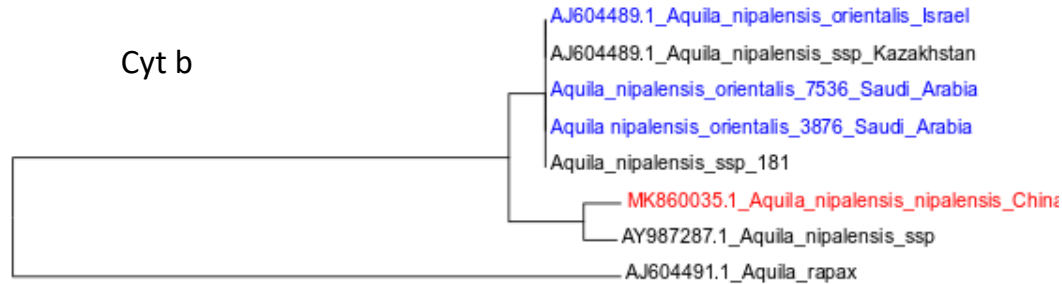
- Apparent zone of intergradation in S Europe
- Clear distance between most of *homeyeri* birds with southern *chrysaetos* and other ssp. by both markers. This may be explained by isolation of the populations during Pleistocene glaciations in two different refugia: Mediterranean and Siberian-Manchurian (de Lattin 1967)
- All ssp. are very close in morphology and ecology (Dementiev 1951)
- Former ssp. *A. c. fulva* (L., 1758) from S Europe may be considered with *homeyeri* and not nominate form
- Taxonomical revision of this species with morphological data is need



Part of the Golden Eagle ssp. range, from Dementiev 1951. 1 – *fulva*, 2 – *chrysaetos*, 3 – *kamtschatica*, 4 – *daphanea*, 5 – *homeyeri*

## *Aquila nipalensis* Steppe Eagle

Species	Steppe Eagle	<i>Aquila nipalensis</i>	Hodgson, 1833	PAL : c
ssp		<i>A. n. orientalis</i>	Cabanis, 1854	e Europe to c Kazakh stan
ssp		<i>A. n. nipalensis</i>	Hodgson, 1833	e Kazakhstan to n China

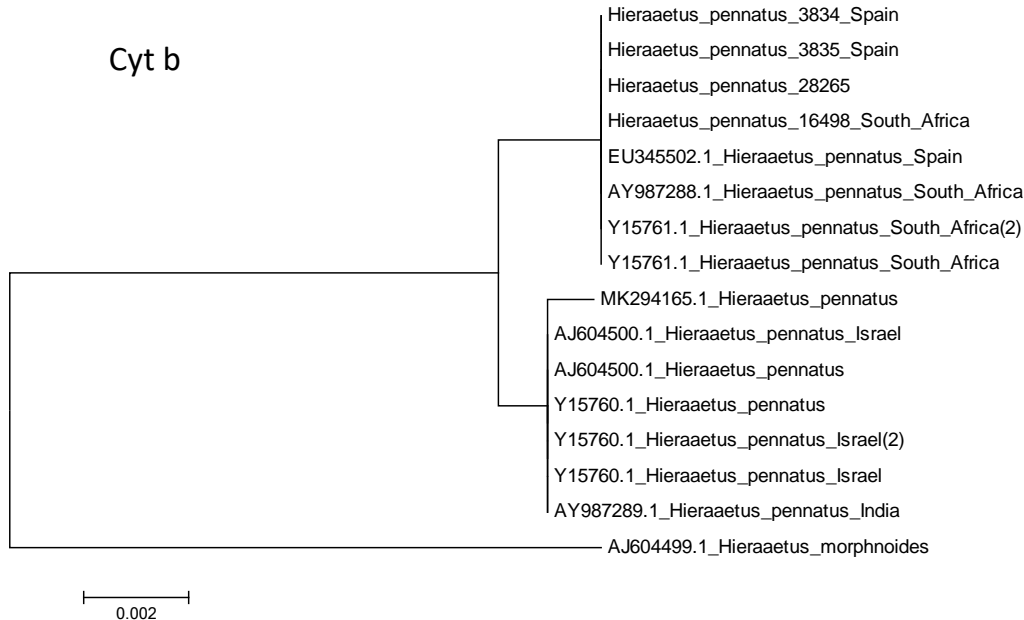


CR haplotypes. Zinevich et al. 2020

- Few Cyt b sequences, but distinct nominate Chinese Steppe Eagle (4 substitutions, K2P = 0.1%)
- No difference in CR sequences between ssp., but same shown for *A. adalberti* – *A. heliaca* complex (Zinevich et al. 2020), which differs significantly by Cyt b (Seibold et al. 1996)
- The question of genetic differentiation of subspecies is still unclear

## *Hieraaetus pennatus* Booted Eagle

Species	Booted Eagle	<i>Hieraaetus pennatus</i>	(Gmelin, JF, 1788)	PAL : sw Europe and nw Africa to c Asia and n India; also S Africa
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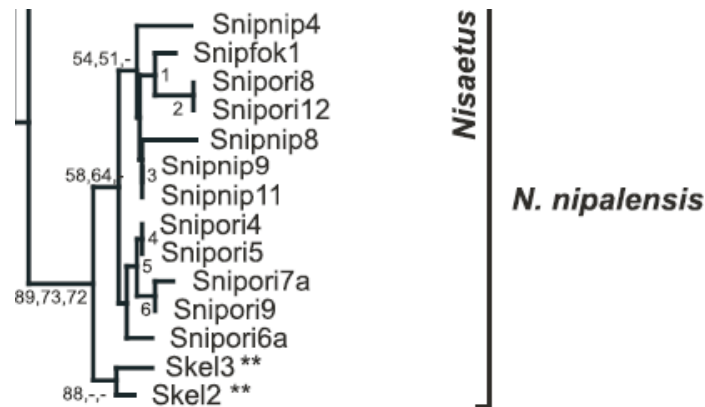
- Two different lineages. K2P = 0.3 – 0.4%
- Recently described ssp. *minusculus* (Y15761, Yosef et al. 2000) is actually invalid
- Formerly accepted *H. p. milvoides* Jerdon, 1839 from C and S Asia may be not a clinal example but a distinct form (different refugium origin). More birds from Asia need

Range of the Booted, Rufous-bellied eagles and Ayres's Hawk-Eagle, from Dementiev 1951. 1 – *H. p. pennatus*, 2 – *H. p. milvoides*, 3 – *H. ayresii*, I – *Lophotriorchis kienerii kienerii*, II – *L. k. formosus*



## Other species

- Only 1 ssp. in the Palearctic, panmixia – Bonelli's Eagle *Aquila fasciata fasciata*, White-tailed Eagle *Haliaeetus albicilla albicilla*
- 2 ssp. in the Palearctic, but no data from the second – Tawny Eagle *Aquila rapax*
- 2 ssp. in the Palearctic, no data from Cyt b and no structure across the range from CR – Mountain Hawk-Eagle *Nisaetus nipalensis*
- Monotypic and no structure – Eastern Imperial Eagle *Aquila heliaca*, Spanish Imperial Eagle *Aquila adalberti*, Greater Spotted Eagle *Clanga clanga*, Lesser Spotted Eagle *Clanga pomarina*, Steller's Sea Eagle *Haliaeetus pelagicus*
- Almost no genetic data from variable markers – Pallas's Fish Eagle *Haliaeetus leucoryphus*, Short-toed Snake Eagle *Circaetus gallicus*



CR tree of the ssp. of the Mountain Hawk-Eagle – *N. n. nipalensis*, *N. n. orientalis* and formerly recognised *N. n. fokiensis*. From Haring et al. 2007



Thank you for your attention!