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Circaetus rhodopensis sp. n. (Aves: Accipitriformes) from the Late Miocene of Hadzhidimovo (SW Bulgaria)

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Abstract: An isolated carpometacarpus from the late Miocene fluviatile deposits of Hadzhidimovo (Blagoevgrad Region, SW Bulgaria) is referred to the first fossil species of Snake-Eagle, described here.

Key words: Snake-Eagles, Fossil birds, Accipitriformes, Late Miocene, Bulgaria

Introduction

After Mlíkovský (2002), Neogene record of accipitrids in Europe includes 16 species of 11 genera: *Palaeohierax gervaisii* (Milne-Edwards, 1863), *Haliaeetus piscator* Milne-Edwards, 1871, *Circaetus* sp., *Accipiter gentilis* (Linnaeus, 1758), *Accipiter* sp., *Buteo pusillus* Ballman, 1969, *B. spassovi* Boev, 1998, *Buteo* sp., *Garganoaetus freudenthali* Balmann, 1973, *G. murivorus* Balmann, 1973, *Aquila* sp., *Hieraaetus edwardsi* (Sharpe, 1899), *H. fasciatus* (Vieillot, 1822), *Polemaetus* sp., *Pelargopappus magnus* (Milne-Edwards, 1868), *Aquila delphinensis* Gaillard, 1939, *A. depredator* Milne-Edwards, 1871), *A. pennnatoides* Gaillard, 1939), *A. prisca* Milne-Edwards, 1863, *Milvus deperditus* Milne-Edwards, 1871, *M. incertus* Gaillard, 1939.

The Neogene fossil record of Accipitridae in Bulgaria includes 14 taxa (Boev, 2012), one of them, *B. spassovi*, has been described from the same locality.

Present paper describes a new Snake Eagle, based on a proximal carpometacarpus. Some data about locality (the site is known also as Hadzhidimovo) and the Neogene record of the accipitrids in Bulgaria have been published by Boev (2002, 2007, 2012).

Material and Methods

The material examined represents a proximal well preserved fragment of a left carpometacarpus (NMNHS 12531, collection of the National Museum of Natural History, Bulgarian Academy of Sciences, NMNHS) and has been identified through the skeleton collections of the NMNHS (Sofia), Natural History Museum (NHM, Tring: 2001, 2003) and the Institute of Systematics and Evolution of Animals (Polish Academy of Sciences) (ISEAK, Krakow: 1998; 2001). The finding has been compared with 30 specimens of 17 recent species (10 genera) of Accipitriformes of similar body dimensions (Table 1).

We follow the systematics of Lerner & Mindell (2005), osteological terminology of Baumell & Witmer (1993) and chronostratigraphy of Mein (1990).

Measurements (in mm; Fig. 1, Table 2).

The measurements have been taken through caliper gauge of 0.05 mm accuracy, but read to the 1st digit after decimal point. All generic names of the binominals are given abbreviated in the text and in full in the tables. 'Smaller/much smaller', 'larger/much larger' in the 'Comparison' sections mean that the fossil specimen differs considerably in size from the specimens of the compared species, and thus their taxonomic identity is excluded.

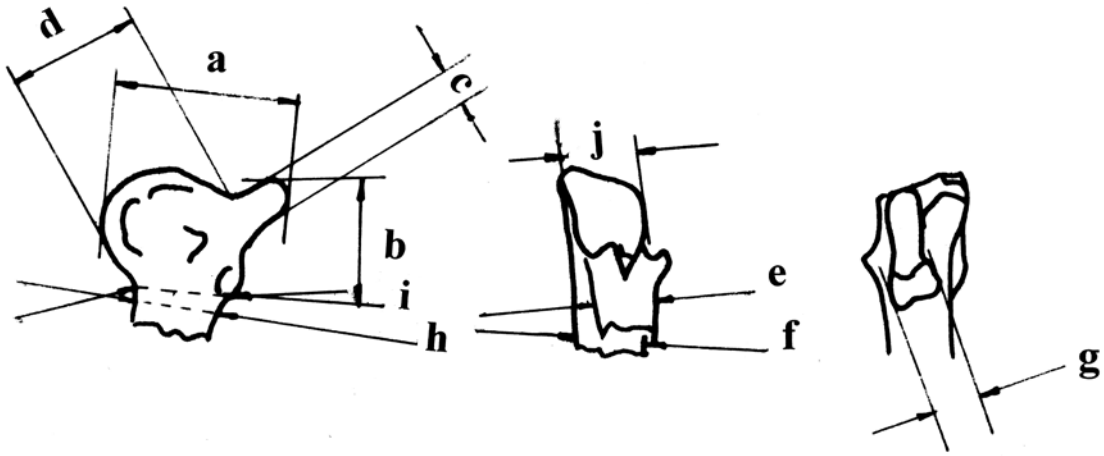

Fig. 1. The manner of measurings of the proximal carpometacarpus (left to right): medial view, caudal view, cranial view (Drawing: Vera Hristova, NMNHS).

Systematic paleontology

Order: ACCIPITRIFORMES Vieillot, 1816

Family: Accipitridae Vigors, 1824

Subfamily: Circaetinae Blyth, 1849

Genus: *Circaetus* Vieillot, 1816

***Circaetus rhodopensis* nov. sp.**

Holotype: NMNHS 12531, carpometacarpus sinistra proximalis (Fig. 2 a, b, c, d), collections of the Vertebrate Animals of the National Museum of Natural History – Sofia, Bulgarian Academy of Sciences. Collected by Mr. Dimitar Kovachev during the 1980s.

Paratypes: No paratypes have been distinguished.

Etymology: The name '*rhodopensis*' is given after the name of the Rhodopes, the mountains of which foothills the find was collected.

Measurements of the holotype: Table 2; Fig. 1 A, B, C.

Differential diagnosis: Medium sized accipitrid, very similar both in morphology and size, to the recent Short-toed Snake Eagle *Circaetus gallicus,* but differing by the (1) sharper edge of condylus lateralis of trochlea metacarpalis in its apical section in lateral view; (2) less concave trochlea in caudal view; (3) more parallel edges of both condyles in caudal view; (4) steeper bend of the edge of the lateral condyle in the area before the inception of the os metacarpale minus; (5) more concave condylus medialis in cranial view (Fig. 2).

Preservation of holotype: The holotype represents a bone fragment, which is broken, but approximately one forth of the presumed length of the whole bone is almost completely preserved. The morphological comparison of the osteological features is given on Table 2.

Locality: Vicinity of the town of Hadzhidimovo near the town of Gotse Delchev (Blagoevgrad District; south-west of Bulgaria), Girizite locality (also known as Hadzhidimovo-1, or Hadzhidimovo-Girizite), 41.30 N, 23.52 E; UTM grid: GM 30. 500 m a. s. l.

Horizon and Chronostratigraphy: Grey-yellowish-colored sands and clay sands of oblique and complex inner stratification at a depth of 1,00-1,50 m. Late Miocene (Turolian = Late Meotian, end of MN 11 – beginning of the MN 12 zone; dated ca. 7.5 mya). The biochronology and the associated fauna of large mammals are examined by Spassov (2002).

Description and Comparison

The find represents proximal fourth of the left carpometacarpus (by the synostosis metacarpalis proximalis). The general morphology of carpometacarpus refers the find to Accipitridae. Three genera (*Aquila*, *Circaetus* and *Buteo*) include species of the same/similar size. Other large accipitrids (vultures, sea eagles, etc.) could be excluded because of the much smaller size of the compared specimen.

Recently two species of buzzards have been described by Sobolev & Marisova (2011), both by distal tibiotarsi from 'Middle Sarmatian' (MN 9) near Gritsev (Khmelnytskyi Region, Western Ukraine). *Buteo parabuteo* Sobolev, 2011 is smaller than recent European species of g. *Buteo*, while thickness of pons supratendineus of *Buteo sarmathicus* Sobolev,

Table 1. List of specimens examined.

Species	Common Name	Family-level, subfamily-level taxon	Specimens
Aquila chrysaetos Linnaeus, 1758	Golden Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NHM 1930.3.24.260, NHM 1996.69.21, ISEAK A 1305/63, ISEAK A 1305/65
Aquila clanga Pallas, 1811	Greater Spotted Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NHM 1952.3.205, NHM 1972.1.58
Aquila fasciata (Vieillot, 1822)	Bonelli's Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NHM 1996.69.22, NHM 1847.10.21.50, NHM 1898.12.13.1, NHM 1847.10.21.50
Aquila heliaca Savigny, 1809	Eastern Imperial Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NMNHS 7/1992, NHM 1954.30.48
Aquila nipalensis (Hodgson, 1833)	Steppe Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NHM 1952.3.58
Aquila pennata (Gmelin, 1788)	Booted Eagle	Accipitridae, Buteoninae (Vigors, 1824)	ISEAK A 3712/80
Aquila pomarina Brehm, 1831	Lesser Spotted Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NMNHS 3/1989, 4/1996, NHM 1995.22.1, NHM 1995.23.1, ISEAK A 2062/69, ISEAK A 4953/91
Aquila audax (Latham, 1802)	Wedge-tailed Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NHM (No unrecorded)
Buteo buteo (Linnaeus, 1758)	Common Buzzard	Accipitridae, Buteoninae (Vigors, 1824)	NMNHS 33/1993
Buteo lagopus (Pontoppidan, 1763)	Rough-legged Buzzard	Accipitridae, Buteoninae (Vigors, 1824)	NMNHS 3/1987
Buteo rufinus (Cretzschmar, 1829)	Long-legged Buzzard	Accipitridae, Buteoninae (Vigors, 1824)	NMNHS 1/1989, NMNHS 3/1989
Circaetus gallicus (Gmelin, 1788)	Short-toed Snake-Eagle	Accipitridae, Circaetinae Blyth, 1849	NMNHS 1/1984
Haliaaetus albicilla (Linnaeus, 1758)	White-tailed Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NMNHS 5/1996
Milvus migrans (Boddaert, 1783)	Black Kite	Accipitridae, Milvinae (Vigors, 1824)	ISEAK A 3926/82
Neophron percnopterus (Linnaeus, 1758)	Egyptian Vulture	Accipitridae, Aegypiinae (Sclater, 1924)	ISEAK A 2864/73
Pernis apivorus (Linnaeus, 1758)	Honey Buzzard	Accipitridae, Perninae Blyth, 1849	ISEAK A 3968/83, ISEAK A 4508/88
Polemaetus bellicosus (Daudin, 1800)	Martial Eagle	Accipitridae, Buteoninae (Vigors, 1824)	NHM 1954.9.1

2011 is bigger, and fossa retinaculi m. fibularis cranialis is deeper than recent European species of g. *Buteo*. The third similar-sized European Miocene accipitrid – *B. spassovi*, is also incomparable to the examined specimen. However the measurements of *B. spassovi* are smaller than *B. rufinus* (Table 1, Boev & Kovachev 1998), while most of the measurements of *C. rhodopensis* sp. n. exceed the measurements of *B. rufinus* (Table 2). Thus, besides morphological differences (see last paragraph of this section), we exclude the taxonomic identity of *B. spassovi* and the compared specimen.

Table 2. Measurements of proximal carpometacarpus in fossil and recent accipitriforms (ref. to Fig. 1).

Species	a	b	c	d	e	f	g	h	i	j
Fossil – Hadzhidimovo										
Circaetus rhodopensis sp. n. NMNHS 12531	17.6	11.2	6.5	11.4	12.8	9.4	4.6	5.7	6.0	7.1
Recent										
Circaetus gallicus NMNHS 1/1984	19.8	11.8	6.0	12.6	9.2	9.5	5.4	6.8	6.7	8.2
Buteo rufinus NMNHS 1/1989	17.1	11.3	6.3	11.5	13.3	8.0	5.0	4.7	5.7	6.6
Buteo rufinus NMNHS 3/1989	17.7	10.3	5.9	11.7	12.8	8.5	4.3	4.8	5.7	7.0
Buteo lagopus NMNHS 3/1987	16.1	9.5	5.2	11.3	11.3	7.6	4.4	4.4	5.2	6.1
Buteo buteo NMNHS 33/1993	14.6	10.2	5.8	11.1	10.5	6.5	4.6	4.0	4.6	5.3
Pernis apivorus ISEAK A 3968/83	15.0	8.0	4.6	8.3	10.6	7.4	3.5	4.1	5.3	6.6
Pernis apivorus ISEAK A 4508/88	14.3	9.0	5.3	8.8	10.4	7.2	3.9	4.0	4.9	6.5
Milvus migrans ISEAK A 3926/82	16.2	8.1	5.8	9.7	11.7	8.5	4.3	4.2	5.3	6.0
Aquila pomarina ISEAK A 2062/69	17.5	11.2	6.8	11.6	13.3	8.7	4.8	5.7	6.3	7.3
Aquila pomarina ISEAK A 4953/91	12.6	11.8	6.8	12.6	13.8	9.3	5.5	5.7	6.0	8.0
Aquila pomarina NMNHS 4/1996	18.8	10.5	6.0	11.7	13.1	8.4	5.0	5.0	5.5	6.9
Aquila pomarina NMNHS 3/1989	18.3	11.6	8.0	12.2	13.4	8.5	5.3	5.1	6.0	8.2
Aquila pomarina NHM 1995.22.1	13.6	11.8	6.8	11.9	13.2	8.7	5.0	5.8	5.6	7.3
Aquila pomarina NHM 1995.23.1	17.4	11.1	6.8	10.9	12.5	8.5	4.8	5.5	5.6	7.4
Aquila clanga NHM 1952.3.205	ca. 18.5	14.5	-	11.5	-	10.1	-	5.8	6.6	8.1
Aquila clanga NHM 1972.1.58	20.0	11.8	7.2	12.5	14.8	9.5	5.3	6.4	6.5	7.6
Aquila heliaca NMNHS 7/1992	24.9	14.6	8.8	15.5	18.2	11.8	6.5	6.5	7.9	10.1
Aquila heliaca NHM 1954.30.48	22.8	14.9	8.0	14.8	16.4	10.7	6.3	7.0	7.4	9.1
Aquila nipalensis NHM 1952.3.58	21.8	13.7	7.6	13.4	16.7	10.1	6.0	6.3	7.4	9.3
Aquila chrysaetos ISEAK A 1305/63	25.2	16.0	9.2	14.6	18.6	12.3	7.0	8.2	7.9	9.7
Aquila chrysaetos NHM 1930.3.24.260	25.0	15.8	9.5	14.2	19.3	12.5	7.0	7.2	8.3	9.0
Aquila chrysaetos NHM 1996.69.21	25.2	18.0	9.9	16.2	19.8	13.8	7.3	7.4	8.5	10.6
Aquila pennata ISEAK A 3712/80	13.8	8.4	5.0	8.6	10.1	7.2	4.2	4.1	4.4	5.4
Aquila fasciata NHM 1996.69.22	19.3	13.0	7.0	12.9	14.8	9.8	5.8	6.5	6.2	8.8
Aquila fasciata NHM 1898.12.13.1	20.6	15.1	7.0	-	14.3	ca. 9.6	5.0	5.8	6.3	8.6
Aquila fasciata NHM 1847.10.21.50	20.6	ca. 14.4	ca. 8.9	12.4	-	9.2	-	6.2	6.2	-
Haliaaetus albicilla NMNHS 5/1996	27.5	15.8	11.8	17.9	20.1	12.6	8.0	7.3	9.1	11.0
Polemaetus bellicosus NHM 1954.9.1	26.0	18.1	9.0	16.0	19.5	12.2	7.4	8.4	8.2	10.3
Pandion haliaetus ISEAK A 2367/71	18.3	12.4	6.6	11.0	12.4	8.9	4.7	4.0	6.0	8.5
Neophron percnopterus ISEAK A 2864/73	ca. 17.7	ca. 12.8	-	ca. 11.6	12.6	8.6	5.0	6.0	6.6	7.9

Although described by proximal carpometacarpus, *Haliaeetus piscator* Milne-Edwards, 1871 is much larger, while *Buteo pusillus* Balmann, 1969 is much smaller than NMNHS 12531. Direct morphological comparisons to the remaining 14 Neogene taxa, described from Europe is impossible due to the lack of analogous finds.

All species of the subfamilies Elaninae, Perninae, Circinae, Milvinae, and Melieraxinae are much smaller, while the species of the subfamilies Aegypiinae, Gypaetinae, Haliaeetinae, and Harpiinae are much larger and could be excluded of our comparison due to their significant size differences.

Polemaetus spp., *A. chrysaetus*, *A. heliaca*, *A. nipalensis*, *A. audax*, *Eutriorchis astur* (Sharpe, 1875) and *Terathopius caudatus* Daudin, 1800 are much larger (Table 1, Thiollay, 1994) and could also be excluded.

The subfamilies Buteoninae, Aquilinae, Polyboroidinae, Accipitrinae, and Circaetinae include species of similar size to specimen No 12531. The subfamily Circaetinae includes 13 modern species in 4 genera: (1) *Circaetus* − Short-toed Snake Eagle, *C. gallicus*, Black-chested Snake Eagle, *C. pectoralis*, Brown Snake Eagle, *C. cinereus*, Southern Banded Snake Eagle, *C. fasciolatus*, Western Banded Snake Eagle, *C. cinerascens*; (2) *Spilornis* – Crested Serpent Eagle, *S. cheela*, Bawean Serpent-eagle, *S.* (*cheela*) *baweanus*, Nicobar Serpent-eagle, *S. minimus*, Mountain Serpent Eagle, *S. kinabaluensis*, Sulawesi Serpent Eagle, *S. rufipectus*, Philippine Serpent Eagle, *S. holospilus*, Andaman Serpent Eagle, *S. elgini*; (3) *Eutriorchis* – Madagascar Serpent Eagle, *E. astur*; and (4) *Terathopius* – Bateleur, *T. ecaudatus*.

In addition fossil taxa, assigned to 10 genera have been described in the family Accipitridae. One of these genera is Paleogene – *Palaeocircus* (Late Eocene/Early Oligocene of France) and 8 are of Neogene, 5 of them from Eurasia – *Garganoaetus* (Early Pliocene of Italy), *Palaeohierax* (Late Oligocene – early Miocene of France), *Mioaegypius* (middle Miocene of Sihong, China), *Gansugyps* (Late Miocene of China), and *Qiluornis* (Miocene of China). One genus is recent – *Buteogallus* Lesson, 1830 (Brodkorb 1964; Mlíkovský 2002). The remaining 2 genera have been described from the New World localities, both of North America – *Neophrontops* Miller, 1916 (Middle Miocene – Nebraska) and *Palaeoborus* Wetmore, 1936 (Miocene – South Dakota).

The specimen clearly fits to Circetinae (*Circaetus*) by the unbroken complete edge (in caudal view) of condylus medialis of trochlea carpalis and medial edge of os metacarpalis minus in the area of the synostosis metacarpalis proximalis. All compared taxa of other subfamilies show a break (interruption) between both edges of these structures in a different degree.

Fossil taxa

Garganoaetus freudenthali Ballmann, 1973 was larger than modern *Aquila chrysaetus*, i. e. it was significantly larger than the specimen of Hadzhidimovo. Both species, *G. murivorus* Ballmann, 1973 and *G. freudenthali*, are known by their tarsometatarsi, i. e. both are not comparable to No NMNHS 12531 (Mlíkovský 2002). They are referred to Buteoninae (Naish, 2008), i. e. to distinct subfamily.

Hieraaetus edwardsi (Sharpe, 1899) is known by a distal end of left tibiotarsus from the Middle Miocene (MN 6) of Sansan, France and by the distal humerus and pedal phalanx (Villalta 1963) from the Middle/Late Miocene (MN 8-9) of Hostalets de Pierola, Spain (Mlíkovský 2002).

Gansugyps linxiaensis Zhang *et al.* 2010 was a vulture significantly larger than the compared specimen. *Mioaegypius gui* was larger than *G. linxiaensis* (Zhang 2010), i. e. larger than No NMNHS12531. *Qiluornis tais*han*ensis* Hou *et al.* 2000 also was a large vulture (Zhang, 2010).

Although *Polemaetus* sp. has been recorded in the Early Miocene (MN 2a) of Saint-Gérand-le-Puy, France and Early Miocene (MN 3) of Tuchořice, Czech Republic (Mlíkovský 2002), the compared specimen is considerably smaller than modern *P. bellicosus* and show morphological differences.

Recent taxa

The specimen differs from: Pandionidae (*P. haliaetus*): by the shallower fossa supratrochlearis and the shallower fovea carpalis cranialis. General morphology fits to large Accipitridae. The morphology of the rear side of the proximal carpometacarpus distinguishes very clearly the g. *Circaetus* from the two other genera, including species of similar size, *Buteo* Lacépède, 1799 and *Aquila* Brisson, 1760 in the recent avifauna of the Western Palearctic.

The specimen differs from: *N. percnopterus*: by shorther synostosys metacarpalis poximalis and narrower trochlea carpalis (measurement 'j'). *P. apivorus*:

Fig. 2. Carpometacarpus sin. prox. of *Circaetus rhodopensis* sp. n. Boev NMNHS 12 531 (holotype), Hadzhidimovo, SW Bulgaria, Late Miocene (Turolian = Late Meotian, end of MN 11 – beginning of the MN 12 zone) (right), and *Circaetus gallicus* (Gmelin, 1788) NMNHS 1/1984, Vlahina Mountain, SW Bulgaria (left): lateral view (a); medial view (b); cranial view (c); dorsal view (d). Photographs: Assen Ignatov.

by larger size, lacking of a concave caudal profile of the trochlea carpalis, and less proximal positioned synostosis metacarpalis proximal; *Buteo rufinus*: by more parallel condyles of trochlea metacarpalis, i. e. more symetrical trochlea metacarpalis, clear junction (transition) in caudal view between the inception of the edge of condylus dorsalis and the inception of os metacarpale minus, although similar in size; *Buteo lagopus* and *Buteo buteo*: by more parallel condyles of trochlea metacarpalis, i. e. more symetrical trochlea metacarpalis, clear junction (transition) in caudal view between the inception of the edge of condylus dorsalis and the inception of os metacarpale, and larger size; *M. migrans*: by less protruding processus alularis and lacking slight constriction in caudal view of os metacarpalis minus in its proximal part; *P. bellicosus*: by much smaller size, blunter processus pisiformis; *S. cheela*: much smaller; *A. audax*: much larger; *H. albicilla*: much larger; *A. pennata*: by considerably larger size; *A. fasciata*: by shorter processus pisisformis, smaller diameter of condylus medialis of trochlea carpalis in cranial view, medio-dorsal, instead caudo-longitudinal direction of the edge of medial condyle of the trochlea carpalis in caudal view; *A. nipalensis*: by smaller size and deeper fossa on the lateral side of the base of processus extensorius; *A. heliaca*: by smaller size, sharper tip on the condylus lateralis of trochlea carpalis, more oval than elongated shape of articular surface of processus extensorius; *A. chrysaetos* by considerably smaller size and lacking of a concave trochlea carpalis in caudal view and relatively narrower processus extensorius; *A. pomarina* by less concave profile of the trochlea carpalis in caudal view, shorter medial condylus in caudal view, ticker processus extensorius in medio-cranial view, but the clearest differences are the thicker part of the synostosis metacarpalis proximalis at the inception of os metacarpalis minus, and shorther processus alularis and processus extensorius, i. e. the correlation 'b:a'; *A. clanga*: by the even, but not slightly concave

caudal profile of the trochlea carpalis, slight constriction on the medial condylus of the trochlea carpalis, sharper processus alularis in medial view, and lateraly outward, than longitudinally directed, medial condylus of the trochlea carpalis in caudal view.

Discussion

Genus *Circaetus* Vieillot, 1816 includes six species in the modern fauna (Thiollay 1994). All are spread in Africa, south of Sahara, and only one of them, the Short-toed Snake-eagle *Cicaetus gallicus* (Gmelin 1788) is distributed also in the Palearctic. Thus we could suggest an African origin of the genus. The suggested existence of the Southeast-European–Southwest-Asian 'superprovince' sensu Bernor *et al.* (1996) or the Greco-Iranian (i.e. Balkan-Iranian) province sensu Bonis *et al*. (1992), during the Middle Miocene was featured by the faunal and environmental similarities across a larger geographical region from the Balkans to Iran and Afghanistan (Geraads *et al.* 2003)). This explains the occurrence of a snake eagle, a species of possible 'African' origin.

The associated avifauna, known from the site of Hadzhidimovo up to the present, includes 5 taxa: ground hornbills (Bucorvini tribe; *Eurocerus bulgaricus* Boev, 2007), Spassov's buzzard (*Buteo spassovi* Boev, 1998), falcons (a kestrel-like falcon *Falco bulgaricus* Boev, 2011) (Boev 2002, Boev & Kovachev 1998, 2007, Boev 2011), *Struthio* cf. *Struthio karatheodoris* Forsyth Major, 1888 (Boev, Spassov 2009). It has been shown that the large mammal fauna and the large bird fauna (ostriches, ground hornbills) indicate a forested savanna (Boev & Kovachev 2007, Boev & Spassov 2009). The presence of a snake eagle is another confirmation of the former occurrence of open landscape, dominated by treeless habitats, favorable for the recent species of g. *Circaetus*.

After Mlíkovský (1996, 2002) the only fossil record of the g. *Circaetus* came from the Late Pliocene of Bulgaria (Varshets, MN 17), citing data of Boev (1996, 2000).

Thus, the find NMNHS 12531 of *Circaetus rhodopensis* sp. n. proves that in the late Miocene at least both subfamilies, Aquilinae Swainson, 1837 and Circaetinae, were separated and their origin must be searched for even in the Early Miocene.

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