

A complete skeleton of *Adcrocuta eximia* (Roth and Wagner, 1854) from the Upper Maeotian (Turolian) of Hadzhidimovo, SW Bulgaria

Dimitar Kovachev

Asenovgrad Palaeontological Branch, National Natural History Museum, Asenovgrad, Bulgaria

(Accepted in revised form: November 2012)

Abstract. A complete and well preserved fossil skeleton of *Adcrocuta eximia* (Roth & Wagner) is described. The skeleton consists of 156 bones. The locality is near the town of Hadzhidimovo, Blagoevgrad district, dated back as Late Maeotian, Turolian faunistic unit, MN12 zone. Comparisons are made with the skeleton of *Chasmaporthetes borissiaki* (Khomenko, 1931). It is concluded that it was an immature individual whose characteristics strongly correspond to *Adcrocuta eximia*. The differences found do not contradict to the taxonomical assignment.

Kovachev, D. 2012. A complete skeleton of *Adcrocuta eximia* (Roth and Wagner, 1854) from the Upper Maeotian (Turolian) of Hadzhidimovo, SW Bulgaria. *Geologica Balcanica* 41(1–3), 77–95.

Key words: Fossil hyaenid, *Adcrocuta eximia*, Maeotian (Turolian), Hadzhidimovo, SW Bulgaria, complete skeleton.

INTRODUCTION

The skeleton of the fossil hyaenid *Adcrocuta eximia* here described was excavated in the Girizite ravine, south of the town of Hadzhidimovo, Blagoevgrad district. It is situated 15 km south-east of the town of Gotse Dlechev in the Mesta Graben that is developed along the Mesta River. The paleontological site is located east of Sadovo village and north of Petrelik village. An almost complete skeleton of the fossil porcupine *Hystrix primigenia* (Wagner) has recently been described from Hadzhidimovo locality (Kovachev, 2012, this volume)

The lithostratigraphy of the Miocene and Pliocene in the Gotse Delchev Basin was presented by Vatshev (1980) and Vatshev and Petkova (1996). Four formations were described from bottom to top: Valevitsa, Baldevo, Nevrokop and Sredna. The fossil hyaenid here described from Hadzhidimovo locality was excavated from the Nevrokop Formation. The underlying Baldevo Formation crops out in the eastern and north-eastern part of the basin. This formation consists of silts, clays and sands, as well as diatomite levels and coal seams. Its age was determined as Pontian-Dacian on the basis of diatom and pollen analysis (Temniskova-Topalova and Ognjanova-Rumenova, 1983; Ivanov, 1995; Yaneva et al., 2002; Ivanov et al., 2011).

The Nevrokop Formation is represented by conglomerates, sands, sandstones, siltstones and clays. It overlays the Baldevo Formation or lies directly on the Precambrian

basement to the west. For decades, the Nevrokop Formation is famous with its rich and well preserved mammal faunas. The fossil collection of Hadzhidimovo 1 locality was made by D. Kovachev and is stored in the Paleontological Museum of Asenovgrad.

The first stratigraphic description of this area was provided by Nenov et al. (1972); Stoyanov et al. (1974). Modern data firmly indicated a Maeotian age, i.e. Turolian stage in terms of mammal stratigraphy, base of MN 12 zone (Spasov, 2000, 2002). It may appear paradoxical that the Nevrokop Formation which in stratigraphic order is “over” is older in age than the Baldevo Formation. It is due to lateral thinning out of the Baldevo Formation westward where the base of Nevrokop Formation is directly on the Valevitsa Formation or on pre-Neogene rocks (see Vatshev, 1980).

SYSTEMATIC PART

Order Carnivora Bowdich, 1826

Family Hyaenidae Gray, 1969

Subfamily Hyaeninae (Gray, 1821) Mivart, 1882

Genus *Adcrocuta* Kretzoi, 1938

***Adcrocuta eximia* (Roth & Wagner, 1848)**

Locality. Girizite site, Hadzhidimovo Town, Blagoevgrad district, SW Bulgaria.

Age. Late Miocene, Maeotian; Turolian faunal unit, MN12 vertebrate zone (Spassov, 2002).

Material. A complete skeleton (Fig. 1), hosted in the Asenovgrad Museum of Palaeontology, a branch of the National Museum of Natural History (NMNH) in Sofia, Bulgarian Academy of Sciences. The 156 bones of the skeleton of a subadult individual are labelled №№ 9316-9472.

Taxonomic notes. *Adcrocuta eximia* was originally described as *Hyaena eximia* Roth & Wagner, then it was attributed to the genus *Crocuto* Kaup, 1928, and finally and now – to the genus *Adcrocuta* Kretzoi, 1938. Werdelin and Solounias (1990) and de Bonis (2005) provided extended synonymic lists of *A. eximia*. The genus *Adcrocuta* is monospecific according to Turner et al. (2008), only *A. eximia* belonging to it. *A. eximia* can be compared to the living spotted hyaena *Crocuto crocuta* (Erleben) according to de Bonis (2005).

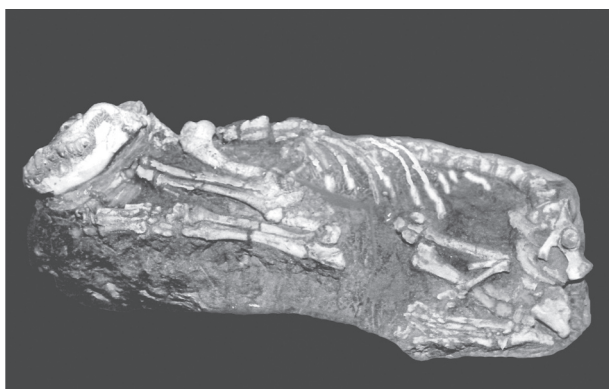


Fig. 1. The skeleton of *Adcrocuta eximia* (Roth & Wagner) from Hadzhidimovo in funeral position.

In Greece, two subspecies of *A. eximia* were recognized: the Vallesian *A. eximia leptoryncha* de Bonis & Koufos, 1981, and the Turolian *A. eximia eximia*. The former subspecies has narrower palate, less compressed jugal teeth raw, and slenderer premolars (de Bonis and Koufos, 1981; Koufos, 2011). Characteristic morphological features of *A. eximia eximia* are the robust teeth, absence of anterior accessory cuspids in the P2, p2, and p3, rudimentary protocone of the P4, absence of metacoid and a small talonid in the m1 (Koufos, 2011).

DESCRIPTION AND COMPARISON

The skeleton of *A. eximia* from Hadzhidimovo will be mainly compared with a skeleton of *Chasmaporthetes borissiaki* (Khomenko, 1931). The latter is an almost complete skeleton of a subadult individual. The animal here described is of the same individual age. In *Ch. borissiaki* the change of deciduous incisors is in the final stage. The premolars and molars are not worn as they

were just erupted. *A. eximia* from Hadzhidimovo is also an immature individual. The deciduous molars were already changed but the constant incisors were not yet completely erupted. The dentition and skull morphology are characteristic of a subadult specimen.

Ch. borissiaki is known from the Ruscinian, MN 15, of Ukraine and France (Turner et al., 2008).

Skull (Fig. 2, Table 1)

The skull is well preserved, although faintly deformed in the area of frontale. The cranium is slightly flattened due to lateral pressure. The visceral part is faintly longer than the cerebral one. Actually, the former is 52%, and the latter is 48% of the basal skull length.

In lateral view, the skull looks quite steep in the area from the intermaxilare to the frontale. This lateral profile line makes an angle of 59° with the alveolar surface. Backwards, this line is straight and almost horizontal in the area of parietale. Premaxilare are well developed.



Fig. 2. Skull. 1. View from above; 1a. View from the left; 1b. View from below.

Table 1
Measurements of skull (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomeenko)
1. Maximal length	280	217
2. Length from the anterior end of I up to the posterior end of condilus occipitalis	225	193
3. Distance between the anterior end of I and procesus postorbitalis	117	114
4. Maximal width at arcus zygomaticus	122	120
5. Length of crista sagitalis	–	42.5
6. Maximal divergence of crista occipitalis	67	70
7. Horizontal diameter of foramen magnum	25	20
8. Vertical diameter of foramen magnum	21	17
9. Width of the canines	54	51
10. Width at the foramina lacrimale	40	53
11. Width at the end of processus postorbitalis	46	52
12. Width at the end of P4	114	92
13. Maximal diameter of the frontal nasal opening	27	26
14. Distance between the canines	34	47
15. Distance between C and the posterior end of P4	84	81.5

All teeth are found *in situ*. Maxilare are also well preserved. There is a well expressed depression in posterior direction from the upper canines. The nasal bones, nasale, are absent. Frontale are found crashed. Thus, the usual concavity in the frontal part looks deeper. Zdansky (1924) stressed on the presence of a frontal depression in *H. variabilis* (= *A. eximia*). Crista sagitalis joints the both cristae temporale, the latter beginning from the tips of the two processi postorbitales. In *A. eximia* these bones form a pronounced convex arch. In *Ch. borissiaki* the sagital crest occupies only the os occipitale, as in the case of our specimen. Crista occipitalis is inclined forwards in *Ch. borissiaki* and in our *A. eximia*.

The position of the eye sockets is from the anterior end of P3 up to the end of P4. Processi postorbitales are blunt. They are not highly elevated above the ossa frontalis and do not touch each other. The eye sockets are closed from the rear. Foramina infraorbitalia are oval in shape and occur above the mid of P3 as in the living *Crocota crocuta* and the fossil *Dinocrocota salonicae* Andrews (Andrews, 1918). According to Gaudry (1862), in *A. eximia* foramina infraorbitalia are located above the posterior halves of P3. In *Ch. borissiaki* they are above the posterior end of P4. The vertical axes of foramina infraorbitalia are longer than the horizontal ones.

Arcus zygomaticus is not quite curved. This is also a characteristic feature of *A. eximia* but not of *Ch. borissiaki*. This bone is 39 mm wide at the frontal end and 21 mm wide at the rear end. The openings of the auditive channels, meatus auditiva, are perfectly circle in our material and in *A. eximia*. In *Ch. borissiaki* they are ellipsoidal with longer vertical axes.

Fossa glendoidalis is located higher than the teeth raw at the level of the auditive channel. The auditive bullae are highly convex and are 31 mm long. At the anterior ends the distance between them is 29 mm, and at the

posterior end it is 40 mm. Processus mastoideus is well developed and fused with the auditive bullae. Processus paroccipitalis is absent. The openings at the base of the skull are not clearly visible. Only foramen magnum is seen. It is of oval outline, its vertical diameter being shorter than the horizontal one.

Mandible (Fig. 3, Table 2)

The lower jaw is perfectly preserved. Only the right processus angularis is slightly damaged and the i2 is absent. The lower surface is horizontal. However, in the rear half below m1 it curves upwards making an angle of 35°. The symphysis is robust and makes an angle of 130° with the lower surface of ramus horizontalis. De Bonis and Koufos (1991) stated that in *A. eximia eximia* it is more vertical than in the living hyaenas. Viewed from the front, it is rectangular in form and gradually passes into the two rami horizontali. The first foramen mentale is located at 10 mm below the p2, right between its two roots. The second and smaller foramen mentale occurs below the posterior part of p3. Much backwards, there is a third, even smaller foramen, below the anterior end of p4. According to de Bonis and Koufos (1991), in *A. eximia* the mandible has foramen mentale located below the roots of p2. In *H. variabilis* (= *A. eximia*) the mental openings could be three in number, sometimes only in one semi-mandibula (Zdansky, 1924).

Fossa masseterica reaches only the talonid of m1 but is clearly expressed. In *Ch. borissiaki* fossa masseterica reaches ahead. The three processes in the rear part of the mandible are quite well preserved. Processus articularis is cylindrical in shape but becomes conical in the outer part. This process is located higher above the alveolar end of the m1, like in *A. eximia*. Processus coronoideus has even upper position and makes an angle of 120° with

the alveolar surface. Its tip is highly curved backwards. Shaping a concave arch, it completely covers processus articularis. The ratio between the height of processus coronoideus and the length of the mandible equals

0.47. It means that processus coronoideus is relatively high. That feature is typical of *A. eximia* but not of *Ch. borissiaki*.

$$\text{Teeth formula } \frac{3 \ 1 \ 4 \ 1}{3 \ 1 \ 4 \ 1}$$

Upper jaw teeth (Tables 3, 4)

Incisors. All incisors are preserved. Only the left I1 is slightly distorted. These teeth are arranged in an arch that is slightly convex anteriorly (Table 3). In *A. eximia* the incisors are arranged in an almost straight line. The size increases from I1 to I3. I2 is faintly bigger than I1, and I3 is considerably larger than I2. In *Ch. borissiaki* these size differences are not as obvious. In *A. eximia* the increasing of incisors from I1 to I3 is similar to that in the described material. At the bases of the lingual side, I1 and I2 have left and right tiny teeth connected in a V-shaped form. I3 is not still completely erupted, so such additional tiny teeth are not seen. The labial faces of all incisors are convex. The erupted tips of the I3 show that the tooth has crushing edges on both the labial and lingual sides. These crushing edges go from the tips down to the tooth base. The crown outline is quite similar to that of *A. eximia* and *Parahyaena brunnea*. In *Ch. borissiaki* the size of I3 is smaller.

Canines. Both the left and right upper canines are not completely erupted showing just halves of their crowns. On their anterior and posterior surfaces two edgings are formed that separate the flat lingual face from the highly convex buccal face.

Premolars. P1 is the smallest premolar with one root and one tip. Its form is skittle-like. There is a small diastema between the C and P1. The labial side is highly convex. The cingulum on the lingual side is better seen.

The P2 is a considerably larger maxilar premolar with two roots and one tip. Crushing edges are seen from the tip down to the anterior lingual surfaces and posterior sides. The both edges end at the base of the teeth where a small tuberculum is formed. A slim talonid is observed in the anterior and posterior parts of the crown. Boule (1893) stated that in *Crocota crocota* the premolars have clear cingula, and rather small talonid. This is the case

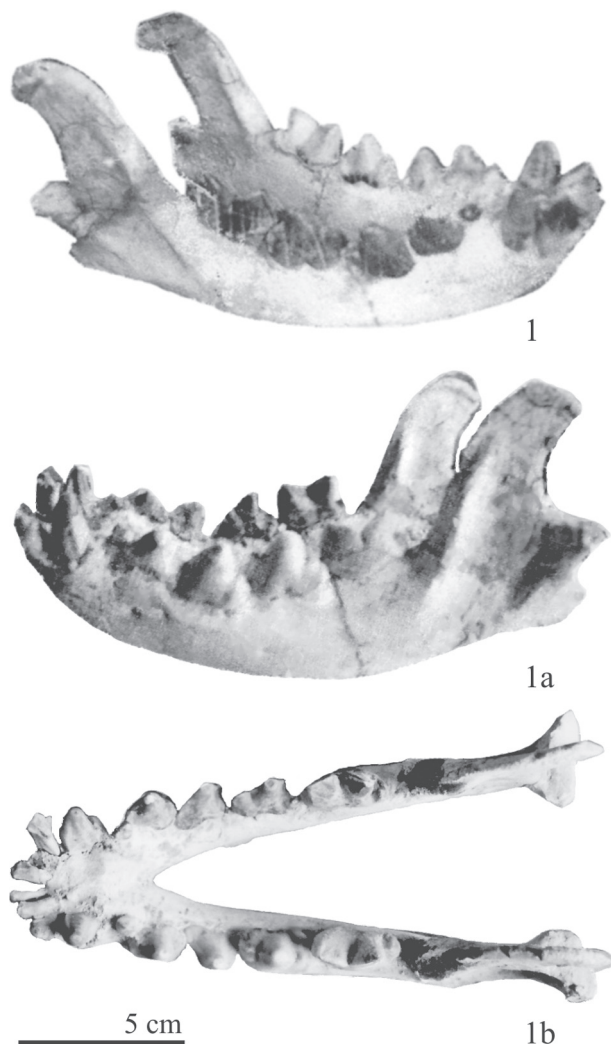


Fig. 3. Mandible. 1. View from right; 1a. View from left; 1b. View from above.

Table 2
Measurements of the mandible (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>A. eximia</i> in Orlov
1. Maximal length	170	162	184
2. Height behind p1	38		
3. Height behind p3	32		
4. Height behind m1	43		
5. Height from pr. angularis to pr.coronoideus	61	61.5	
6. Thickness behind p1	20		
7. Thickness behind p3	20		
8. Thickness behind m1	14		15.5
9. Angle between the symphysis and the lower surface of ramus mandibuli	130°		

Table 3
Measurements of the upper jaw teeth (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
1. Length I-P4	121	–	–
2. Length C-P4	94.0	85.4	91.7
3. Length P1-P4	81.0	75.4	76.4
4. Length P2-P4	76.0	–	–
5. I1 length	6.0	4.1	5.2
6. I1 height	8.0	7.4	9.0
7. I2 length	8.0	5.3	5.8
8. I2 height	10.2	7.4	11.2
9. I3 length	9.4	8.0	14.3
10. I3 height	16.7	14.9	18.6
11. C length	13.9	8.2	16.4
12. C height	20.0	14.5	28.0
13. P1 length	7.6	8.2	7.4
14. P1 width	7.7	6.8	6.2
15. P1 height	6.0	8.4	–
16. P2 length	18.6	14.7	14.6
17. P2 width	12.4	–	6.2
18. P2 height	13.2	12.9	6.0
19. P3 length	20.0	19.6	20.6
20. P3 width	15.3	–	–
21. P3 height	20.0	15.6	21.5
22. P4 length	38.0	32.9	34.9
23. P4 width	18.9	14.1	18.7
24. P4 height	22.0	18.8	18.7

Table 4
Measurements of the transversal diameters of the upper jaw incisors (mm)

	<i>A. eximia</i> from Hadzhidimovo		<i>Ch. borissiaki</i> (Khomenko)
	sin	dex	
I ₁	–	5.7	4.1
I ₂	7.0	6.0	5.3
I ₃	12.7	12.2	8.0

with the described material. The general outline of the P2 is almost rectangular. The anterior surface is 1.5 mm longer than the posterior one. Such a feature is characteristic of the genus *Adcrocuta*.

P3 has the same characters like P2 being, however, broader and higher. Both the P2 and P3 are robust, with blunt tips. In *A. eximia leptoryncha* de Bonis & Koufos, 1981, these two premolars are slenderer.

According to Koufos (1995), the P3 in *A. eximia eximia* have clearly outlined accessory cuspids. The same is valid of the P3 from Hadzhidimovo. The posterior cuspid derives from the cingulum. Kurtén (1957) considered this feature as typical of the crocutans. The ratio P2/P3 is 0.93. Thus, there is no “jump” in dimensions. Reynolds (1902) mentioned such a “jump” in sizes in the living hy-

aenids and Table 3 shows the same of *Ch. borissiaki*. In the genus *Crocuta* Kaup the P3 are not quite larger than the rest of the premolars (Barry, 1987).

P4. The protocon is clearly shaped and lies lingually between the parastil and the paracon. Koufos (1995) described the protocon of *A. eximia* as strongly reduced, as well as Chen and Schmidt-Kettler (1983) in the hyaenids and Kurtén (1957) in the genus *Percrocuta* Kretzoi. The most important differences with *Ch. borissiaki* are well expressed in the P4. The total length of the P4 equals 98% of the sum of P2+P3 length (Table 3).

Molars. The **M1** are absent. Only a small part of the root of the right M1 is preserved in the maxilla.

All the premolars and the molar touch each other without overlapping or leaving free spaces.

Lower jaw teeth (Fig. 3, Table 5, 6)

Incisors. The position of i2 is specific since its roots are strongly inclined and occur posteriorly than those of i1 and i3. Simeonescu (1930) reported a finding of *A. eximia* in which the i2 were pushed backwards. In *Ch. borissiaki* there is a difference in the sizes of i2 and i3. Khomenko (1931) even regarded that feature as a diagnostic of the latter species.

Canines. The mandibular canines are not completely erupted. However, compared to the upper jaw canines they are more developed. This is evidenced by the bigger sizes and the beginning of attrition of the tips in the lower jaw canines. The lingual faces are flat. Their anterior and posterior ends show vertical grooves. The labial faces are smooth and rounded, and the tips are slightly curved backwards. A small diastema of 5 mm separates

the canines from p1 in our material against 5-8 mm of the same diastema in *H. variabilis* (= *A. eximia*) according to Zdansky (1924).

Premolars. The p1 are absent in the living hyaenids. In our material the position of p1 is over the internal part of the ramus horizontalis. The p1 have one root. They are closely approached to the antero-lingual sides of p2. The crowns of the p1 have clear cingula. The angle between these crowns and the axis of p2 is 155°. A sharp edge passes along the entire p2 dividing the crown into an inner concave and an outer convex part.

The p2 are considerably bigger. They have two roots. A central tip dominates that is insignificantly worn. This central tip gives rise to two edges, anterior and posterior ones, reaching up to the cingulum. There they form two small bulges, one anterior and the other posterior. The p2 have four sides, two by two parallel.

The p3 have the same features like the p2. However, there are differences which are as follows: 1) the p3 are more robust; 2) they do not possess anterior tips; 3) their position is lower than that of the p2; and 4) the anterior part of the p3 directs lingually, and the posterior part – labially. Thus, the angle between the p2 and p3 is 155°. The ratio p2/p3 is 0.78. The index of the p3 equals 91 showing its hypsodonty (Kurtén, 1956).

The p4 are the most robust amongst the premolars. They have a worn central tip. In front of and behind it there are well developed talonids and very faint posterior tips. In *Ch. borissiaki* the paraconid is bigger, whereas the protoconid is smaller. Khomenko (1931) compared the sizes of the p3 and p4 and reached the conclusion that the ratio between them is of no taxonomic value.

Mollar. The m1 has a longer paraconid and a higher protoconid. The talonid has one cuspid. Despite of its later stratigraphic appearance, *A. eximia* has a more developed talonid. In this feature the species differs from the Percrocutidae (Schmidt-Kittler, 1976). According to Pilgrim (1931), the presence of metaconid is diagnostic of the genus *Hyaena* Linnaeus, and its absence – of the genus *Crocota*. Pilgrim (1932) and de Mecquenem (1925) stated that in some cases the m1 in *A. eximia* have a metaconid. Zdansky (1924) was convinced that metaconid is absent in *A. eximia* and the paraconid is slightly shorter than the protoconid. We observed just the opposite in our material. The m1 are faintly worn. The ratio p4/m1 equals 0.90. The latter two teeth occur in a straight line, whereas the p3 and p4 make an angle of 150°. The position of the lower molar and premolars in relation to the mandibular axis is different, only the m1 occurring right in the middle of the lower jaw. This is a common feature of both *A. eximia* and *Ch. borissiaki*.

Table 5
Measurements of the lower jaw teeth (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)
1. Length i1-m1	115	–
2. Length p1-m1	96.0	84.7
3. Length p2-m1	87.4	79.7
4. i1 length	7.0	2.5
5. i1 height	7.0	4.0
6. i2 length	9.0	4.7
7. i2 height	9.3	5.0
8. i3 length	8.6	5.8
9. i3 height	12.4	9.8
10. c length	11.0	5.0
11. c height	18.2	10.4
12. p1 length	6.0	5.0
13. p1 height	6.0	–
14. p2 length	16.3	15.4
15. p2 height	14.0	–
16. p2 width	–	–
17. p3 length	20.8	19.0
18. p3 height	19.0	15.0
19. p3 width	–	–
20. p4 length	24.8	21.3
21. p4 height	18.3	–
22. p4 width	–	–
23. m1 length	27.0	24.0
24. m1 height	18.2	14.6
25. m1 width	12.4	10.4

Table 6
Measurements of the transversal diameters of the lower jaw incisors (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
i1	4.0	2.5	3.5
i2	6.0	4.7	4.6
i3	8.4	5.8	7.7

Columna vertebralis

A total of 35 vertebrae have been found that are distributed as follows: 7 vertebrae cervicales, 13 thoracales, 5 lumbales, 3 sacrales, and 7 caudales.

Vertebrae cervicales C1–C7 (Fig. 4. 1)

Atlas C1 (Table 7). It consists of acrus anterior and acrus posterior. Processus transversus is slightly developed on both sides.

Epistropheus (Axis) C2 (Table 8). The second cervical vertebra is characterized by its considerable length from the posterior end of the processus odontoides to the dorsoventral end of its body. Processus spinosus is not much high, although its length of 73 mm is impressive. The transversal diameter at the posterior zigapophysis is relatively small.

C3–C7. The length and width of the rest of cervical vertebrae are given in Table 9. According to Khomenko (1931), the length of the cervical vertebrae behind the epistropheus slightly diminishes in *Ch. borrisiaki*. Such a pattern has not been observed in *A. eximia* from Hadzhidimovo.

Vertebrae thoracales Th1–Th13 (Fig. 4. 2, Table 9)

The length of these vertebrae decreases up to Th5, and then increases from Th6. Processus spinosus is broken in Th1 to Th3. Despite of it, it is clearly visible that the dimensions of Th1 to Th3 are larger than that of the cervical vertebrae. Processus spinosus in Th4 to Th7 is well preserved being in vertical position. Starting from Th6 there is a tendency of progressive inclination backwards. The latest vertebrae thoracales are almost horizontal.

Vertebrae lumbales L1–L5 (Fig. 4. 2, Table 9)

Processus spinosus is inclined like in the previous vertebrae but this time forwards. The vertebrae lumbales are the most massive among all vertebrae. Spinal processes are less developed.

Vertebrae sacrales S1 – S3

Three in number, the vertebrae sacrales are fused with each other representing the rigid part of the vertebral column. The os sacrum is formed due to their fusion. Canalis sacralis penetrates through the entire length of

the os sacrum. Processus spinosus is preserved only in S2. The length of the process is 15 mm, and the antero-posterior diameter at the base is 22 mm. Seemingly,

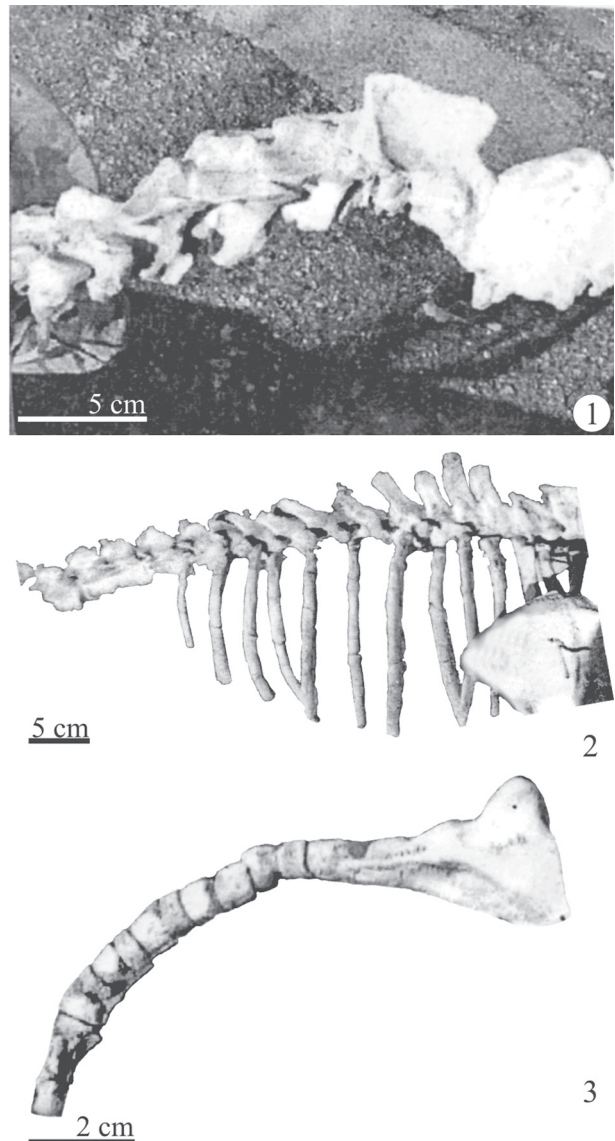


Fig. 4. Vertebral column.

1. Cervical vertebrae, lateral view;
2. Thoracic and lumbar vertebrae, lateral view;
3. Caudal vertebrae, lateral view.

Table 7
Measurements of the atlas (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
1. Maximal width	78.0	76.0	125.0
2. Distance between the tuberculum superior and tuberculum inferior	37.0	31.0	35.5
3. Maximal distance between fovea articulares anteriores	51.0	44.5	49.5
4. Maximal width of the foramen vertebrale	26.0	22.0	27.0

Table 8
Measurements of the axis (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
1. Length of dens axis from the anterior to the posterior-ventral end	73.0	70.0	67.7
2. Height between the arei vertebræ and the processi spinosi	19.0	20.0	24.5
3. Transversal diameter of the front zigapophyses	–	41.0	49.0
4. Transversal diameter of the rear zigapophyses	41.0	46.0	52.5

S1 and S3 have never had such a process as there are no traces of breaking at their dorsal sides. The general form of the sacral crest (crista sacralis) is a highly elongated triangle. Its maximal length is 84 mm. The width at the anterior end is 35 mm, and that at the posterior end is 28 mm.

Table 9
Measurements of the vertebrae (mm)

Vertebrae	Length	Width
Cervicales		
C/3	38	42
C/4	38	44
C/5	38	45
C/6	42	43
C/7	43	40
Thoracales		
Th/1	23	19
Th/2	23	19
Th/3	18	18
Th/4	16	15
Th/5	14	16
Th/6	15	16
Th/7	18	18
Th/8	18	18
Th/9	18	18
Th/10	18	17
Th/11	21	19
Th/12	22	19
Th/13	16	16
Lumbales		
L/1	31	24
L/2	35	23
L/3	36	27
L/4	35	27
L/5	34	31
Caudales		
Ca/1	18	10
Ca/2	17	9
Ca/3	14	9
Ca/4	13	9
Ca/5	11	8
Ca/6	10	8
Ca/7	20	7

Vertebrae caudales (Fig. 4. 3, Table 9)

Seven caudal vertebrae have been found. No doubt, these seven vertebrae represent a succession. Probably, a couple of caudal vertebrae are absent, as there is a jump in the dimensions between the last sacral vertebra and the first found caudal vertebra. The most anterior found vertebrae caudales possess highly elongated prismatic bodies that narrow dorsally.

Costae (Ribs)

The position of the found right and left ribs in relation to the vertebral column is given in table below. The total

Costae dex	+ + + + + + + +												
Columna vertebralis	1	2	3	4	5	6	7	8	9	10	11	12	13
Costae sin	+ + + + + + + +												

number of the ribs found is 17, nine of them left, and eight – right. The eleventh pair of ribs is absent. The costae in the most proximal position that are closer to the skull are shorter. Up to the ninth pair, the length and width of the ribs increase, and then they decrease in distal direction. Sternum has not been found. Cartilago costales were not preserved on the rib bones. There is no doubt that the total number of rib pairs was 13, as the fovea costalis is present up to the Th13.

Bones of the fore limb (Fig. 5. 1)

Scapula (Fig. 5. 1, Table 10)

This is a flat bone surrounded by three margins, namely: margo superior, margo anterior and margo posterior. The upper margin (margo superior) is the thickest one. The front margin (margo anterior) is a convex arch, and the back margin (margo posterior) is straight. The scapula has two surfaces: an inner surface (facies costalis) and an outer surface (facies laterals), the latter surface dividing the spina scapulae into fossa supraspinata and fossa infraspinata. Towards its lower end the bone narrows forming a neck that terminates with a specific surface, the fossa

Table 10
 Measurements of the scapula (mm)

	<i>A. eximia</i> Hadzhidimovo		<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
	sin	dex		
1. Maximal height	155.0	140.0	149.6	176.2
2. Antero-posterior diameter of the neck	40.0	42.0	34.0	39.4
3. Maximal height with spina scapule	14.0	14.0	29.0	33.0
4. Antero-posterior diameter of fossa glenoidalis	40.0	4.0	37.0	40.5
5. Width	90.0	90.0	113.5	122.0

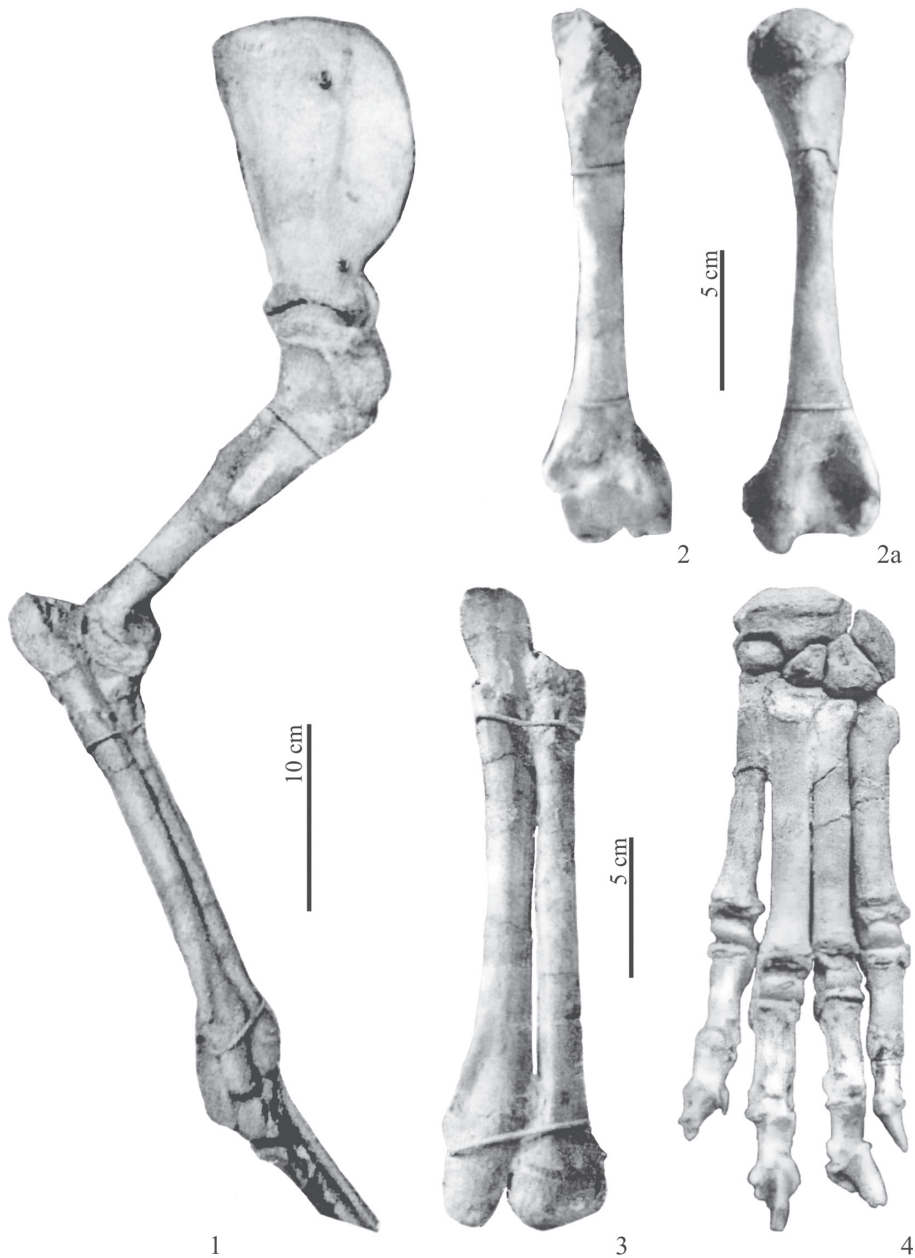


Fig. 5. Bones of the fore limb.
 1. Complete fore limb with scapula, lateral view;
 2. Humerus, frontal view; 2a. Humerus, back view;
 3. Ulna and radius taken together, lateral view;
 4. Foot (carpus, metacarpus and fingers), view from above.

glendoidalis. Spina scapulae are completely straight as are in *Ch. borissiaki*.

Table 8 shows different dimensions of the left and right scapulae. This is due to the fact that the left scapula was found highly cracked. Thus, the measurements of the right scapula are authentic. In comparison with *Ch. borissiaki*, the bone here described is 10 mm shorter and 23 mm narrower. However, in general outline the scapula is very similar in the both species.

Humerus (Fig. 5. 2, Table 11)

Both the left and right shoulder bones are preserved. Their dimensions are equal. At the proximal ends the bones possess caput humeri. Its joint surface is involved in the formation of the shoulder joint. The tip of the tuberculum majus rises above it only 3 mm. The small tuberculum (tuberculum minus) is well shaped in the cranio-medial part. A wide but shallow groove, sulcus intertubercularis, separates the two tubercula. Tuberosites deltoidea occurs in the upper thirds of the shoulder bones and gives rise to crista humeri that goes distally up to the mid of the bones. The diaphysis is of trigonal outline with the facies anterior lateralis, facies anterior medialis and facies posterior. In their distal parts, the trochleas, epicondylus and the crests between them are well preserved. The elbow groove, fossa olecranon, is significantly deep and wide. The elbow concavities, fossa olecranon, are rather deep

and broad. There are no foramen entepicondyloedium, neither foramen supratrochleare in the described material. *A. eximia* in Gaudry (1862) also lacks these features. On contrary, in *Ch. borissiaki* they are well developed.

Ulna (Fig. 5. 3, Table 12)

The position of the ulna is along the lateral part of the forearm. The ulna is considerably longer than the radius. Its proximal epiphysis possesses strong ulnar tuberosities (olecranon) that terminate at their posterior parts by tuberositas olecrani. In front of them there are two processes: processus coracoideus and processus coronoideus. Between them are included incisura semilunaris that connect the bones with the trochleas of the shoulder bones. Their diaphyses, corpus ulnae, are of trigonal shape. The distal epiphyses form the heads and bear the fassetas for articulation with the radius, as well as with the cunei-forme of the carpus. Dimensions in Table 10 show that these bones are much longer in the described skeleton than in *Ch. borissiaki*.

Radius (Fig. 5. 3, Table 13)

Both the left and right bones are completely preserved. Their position is along the medial side of the forearm. The upper part of the radius connects with the humerus, and the lower part – with the metacarpal bones. The ra-

Table 11
Measurements of the shoulder (mm)

	<i>A. eximia</i> Hadzhidimovo		<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
	sin	dex		
1. Maximal length	195.0	195.0	200.0	208
2. Diameter at the proximal end at the mid of caput humeri and tuberculum majus	55.0	60.0	57.5	63.0
3. Vertical diameter of corpus humeri at the mid of crista deltoidea	24.0	25.0	28.0	32.5
4. Maximal transversal diameter at the distal end	53.0	53.0	44.0	44.0
5. Dorso-plantar diameter of olecranon	41.0	40.0	–	–
6. Proximo-distal diameter of olecranon	35.0	40.0	–	–
7. Maximal width of trochlea	45.0	45.0	36.5	43.3

Table 12
Measurements of the ulna (mm)

	<i>A. eximia</i> Hadzhidimovo		<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
	sin	dex		
1. Maximal length	230.0	232.0	225.0	243.5
2. Transversal diameter at the proximal end	16.0	17.0	17.5	22.1
3. Antero-posterior diameter at the proximal end	41.0	42.0	35.5	36.0
4. Transversal diameter of the diaphysis	11.0	12.0	–	–
5. Antero-posterior diameter of the diaphysis	14.0	15.0	–	–
6. Transversal diameter at the distal end	31.0	31.0	21	11.5
7. Antero-posterior diameter at the distal end	24.0	26.0	9.3	14.7

Table 13
Measurements of the radius (mm)

	<i>A. eximia</i> Hadzhidimovo		<i>Ch. borissiaki</i> (Khomeiko)	<i>Cr. crocuta</i> in Khomeiko
	sin	dex		
1. Maximal length	188.0	190.0	194.0	209.0
2. Transversal diameter at the proximal end	27.0	23.0	25.5	29.7
3. Antero-posterior diameter at the proximal end	22.0	23.0	18.7	20.0
4. Transversal diameter at the distal end	42.0	40.0	–	35.0
5. Antero-posterior diameter at the distal end	30.0	28.0	–	23.5
6. Transversal diameter of the diaphysis	20.0	18.0	16.2	19.0
7. Antero-posterior diameter of the diaphysis	14.0	16.0	15.0	11.5

dius is flattened antero-posteriorly along its entire length. In the middle part of the diaphysis there is a slight convexity directing forwards. The proximal epiphysis forms the head of the radius, caput radii that is with slightly hollowing articulate surfaces. Circumferencia articularia are presented like narrow smooth horizontal bands on the entire bone. Beneath them, the neck of the bone, collum radii, is clearly visible. The distal ends are stouter. There, processus styloideus dominates. Compared to *Ch. borissiaki*, these bones are shorter and more robust at both ends. Orlov (1941) compared the radius in *A. eximia* and the living hyaenas. He mentioned that the radius in *A. eximia* is longer, slenderer and with deeper fassetas in the distal part for articulation with the ulna. All these features have been observed in our material in greater extent.

Carpus (Fig. 5. 4, Table 14)

The carpus of the fore limb consists of six bones arranged in two rows. The proximal row includes scapholunare, cuneiforme, and pisiforme; the distal row includes trapezoid, magnum, and unciforme.

Scapholunare. This bone is highly elongated in lateral direction. It is the largest bone of the carpus. Its proximal part connects with the radius, and its distal part lies over the bones of the distal row: trapezoid, magnum, and unciforme. The dorsal surface wedges deep between the trapezoid and magnum. The fasseta making connection with the unciforme is broad and occurs almost completely in the lateral surface. Thus, the articulation between these two bones approaches a horizontal position. There is no fasseta for connection with the trapezoid since the lat-

Table 14
Measurements of the carpus (mm)

		<i>A. eximia</i> from Hadzhidimovo	
		sin	dex
Maximal total length of the carpus		23.0	23.5
Maximal total width of the carpus		46.0	46.5
scapholunare	length	27.0	27.0
	width	32.5	32.5
	antero-posterior diameter	22.0	21.0
pisiforme	length	33.0	32.0
	width	12.0	11.0
	antero-posterior diameter	16.0	14.5
cuneiforme	length	22.0	22.0
	width	15.0	14.5
	antero-posterior diameter	14.0	14.0
trapezoid	length	11.0	13.0
	width	12.0	10.0
	antero-posterior diameter	17.0	16.0
magnum	length	11.5	14.0
	width	11.0	–
	antero-posterior diameter	12.5	16.0
unciforme	length	18.0	17.0
	width	17.0	16.0
	antero-posterior diameter	20.0	20.0

ter bone and the entire first finger are reduced. A deep fasseta for the magnum is located on the posterior surface. According to Orlov (1941), the proximo-distal and dorso-plantar diameters of scapholunare in *A. eximia* are bigger than those in the living spotted hyaena.

Unciforme. This bone is quadrangular in shape. It is slightly concave. The surface is rough. The proximal surface of the unciforme articulates with the scapholunare. On the plantar surface there is a fasseta for the pisiforme. Orlov (1939) mentioned that this fasseta is faint in the spotted hyaena because the pisiforme itself is also faint. The distal surface of our specimen is almost flat and divided into two fassetas by an edge. One fasseta is for the MC-IV, and the other is for MC-V. The proximal diameter measured on the dorsal surface is 20 mm, and that on the plantar side is 13 mm.

Pisiforme. This is an elongated small bone that articulates with the unciforme and with cuneiforme. There is a pronounced pea-shaped tuberculum in the proximal part.

Cuneiforme. This is the outermost small carpal bone. Its position is between the proximal and distal rows. The form of cuneiforme is a triangular wedge that articulates with the unciforme, pisiforme, as well as with the distal end of ulna.

Magnum. It is smaller than the rest of the carpal bones and it is only bigger than the trapezoid. In proximal direction the magnum articulates with the scapholunare. Distally it lies over the proximal part of MC-III. Its inner surface is in contact with the trapezoid, and the outer surface – with the unciforme.

Trapezoid. This is the smallest carpal bone. Its dorsal surface is rounded tetragonal to elliptical. Trapezoid lies entirely on the MC-II. The connecting fasseta for MC-II is strongly convex. In plantar view, a thin process is seen that is faintly curved downwards.

Metacarpus (Fig. 5. 4, Table 15)

It consists of four bones. These bones are well preserved in both the left and right metacarpus, although some are slightly deformed. Measurements are given in Table 15.

The bones of metacarpus are longer in their proximal ends compared to those of the metatarsus. The corpus of the entire metacarpus, i.e. the four bones, represents a common site for connection with the distal row of the carpal bones. It looks like a three-step cascade. The lowest step serves for connection with the unciforme, the higher one – for connection with the magnum, and the highest step – for connection with the trapezoid. This three-step configuration is due to the different length of the carpal bones.

MC-I is not developed at all.

MC-II is sub-cylindrical, like the other MCs. The proximal epiphysis has a fasseta for connection with the trapezoid, and another one for articulation with MC-III. The second fasseta is on the outer surface of MC-II and is not quite deep. Such a shallow fasseta is typical of the hyaenas according to Pilgrim (1931). In distal direction the MC-II connects with the first phalange of the second finger by means of a symmetrical cylindrical trochlea.

MC-III is the longest metacarpal bone. The only difference with MC-II is that the proximal and distal epiphyses are bigger. Like the other metacarpal bones, MC-III is straight. Without any dorsal curves, its form is of dorso-plantarily flattened cylinder.

MC-IV. The proximal end is subducted beneath the MC-III. Such a connection is more secure. The proximal end of MC-IV articulates with the unciforme.

MC-V is also subducted beneath the MC-IV. The proximal fasseta has two distinct lobes for connection with the unciforme and cuneiforme.

Phalanges (Fig. 5. 4, Table 16)

The first phalange in all fingers is faintly dorso-plantarily compressed. At the distal end it is slightly elevated. In the second and third fingers these bones are insignificantly shorter. The trochleas at the distal ends are symmetrical in the first, second and third fingers. The third phalanges form the nails. They would be possibly able to elevate high above the trochleas of the second phalanges. The nails were not reactive like in the cats.

Table 15
Measurements of the metacarpus (mm)

		length	Proximal part		Distal part		Diaphysis	
			antero-posterior diameter	transversal diameter	antero-posterior diameter	transversal diameter	antero-posterior diameter	transversal diameter
MC II	dex	77	19	12	12	12		11
	sin	15	14	12	15		~11	–
MC III	dex	89	22	15		16		13
	sin	87	23.5	16	12	16	–	~11
MC IV	dex	84	18	14		14		14
	sin	84	19	–	–	12	–	10
MC V	dex	71	16	18	12	14		10
	sin	81	16	17	13	14	8.5	10

Table 16
Measurements of the fingers of fore limb (mm)

Fingers		Length
f I-1	dex	27
	sin	30
f I-2	dex	18
	sin	18
f I-3	dex	17
	sin	
f II-1	dex	29
	sin	30
f II-2	dex	22
	sin	19
f II-3	dex	19
	sin	12
f III-1	dex	28
	sin	28
f III-2	dex	16
	sin	15
f III-3	dex	14
	sin	17
f IV-1	dex	25
	sin	23
f IV-2	dex	16
	sin	16
f IV-3	dex	14
	sin	–

Bones of the hind limb (Fig. 6. 1)

Pelvis (Fig. 6. 2, Table 17)

The two nameless bones (os coxae) are fused with each other and in dorsal direction with the sacrum (os sacrum) which is the third component of the pelvis. Each of the nameless bones consists of three fused bones: os ilium, os ischii, and os pubis. Flank bone (os ilium) occupies most of the pelvis. It builds the broader upper part. The seatbone (os ischii) occupies the lower part. The pubic bone (os pubis) builds the frontal part surrounding the articulate concavity, acetabulum. Beneath the acetabulum there is a preserved foramen obturatorium.

Table 18
Measurements of the femur (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
1. Maximal length	220	229	229
2. Transversal diameter at the proximal end	57.0	–	61.7
3. Antero-posterior diameter of the diaphysis	17.0	21.0	15.4
4. Transversal diameter of the diaphysis	20.0	14.7	20.4
5. Antero-posterior diameter at the distal end	46.0	44.5	47.0
6. Transversal diameter at the distal end	57	43.7	51.6

Table 17
Measurements of the pelvis (mm)

1. Maximal length	161.0
2. Width at the upper end	58.0
3. Width at the lower end	77.0
4. Width in the middle part	28.0
5. Horizontal diameter of acetabulum	29.0
6. Vertical diameter of acetabulum	32.0
7. Antero-posterior diameter of foramen obturatorium	27.0
8. Lateral diameter of foramen obturatorium	26.0
9. Angle between the pelvis and the vertebra	140°

Femur (Fig. 6. 3, Table 18)

Only the right hipbone is preserved. Although deformed along its length, the femur shows all important morphological characteristics. The proximal epiphysis has a clearly outlined head, caput femoris, with visible fovea capitis. The neck, collum femoris, is 14 mm long and makes an angle of 100° with the corpus of hipbone, i.e. they are almost perpendicular. Trochanter major occupies a lateral position, and trochanter minor is located in medial position beneath the neck. The surfaces of both trochanters are damaged. The same is valid of crista intertrochanterica.

The diaphysis, corpus femoris, is convex forwards. It is deformed due to pressure. The distal epiphysis consists of condylus medialis and condylus lateralis that are separated by the fossa intercondylaris. On the back surface of hipbone, at 20 mm higher than the condyli, there are two small papules. The right papule is considerably bigger than the left one. Measurements in the Table 18 show that the femur in the described specimen is larger than in *Ch. borissiaki*. Differences in the diameters of epiphyses in *A. eximia* and *Ch. borissiaki* are not as pronounced.

Patella

Only the left patella is preserved. It is an oval flat plot. The transversal diameter is 15.5 mm, and the ventral one is 18 mm. The sharper end of this bone (we accept it as the apex patellae) is directed downwards. Patella is the biggest sesamoidal bone.



Fig. 6. Bones of the hind limb
 1. Complete hind limb, lateral view;
 2. Pelvis, lateral view;
 3. Femur, frontal view; 3a. Femur, back view;
 4. Tibia, back view.

Tibia (Fig. 6. 4, Table 19)

The right tibia is preserved. It is shorter than the hipbone. The most robust part is the proximal epiphysis with condylus lateralis and condylus medialis. Each condylus has a fasseta articularis for connection with the femur. This surface is not concave as one might expect. Eminencia interfascialis lies in the middle part. The diaphysis, corpus tibiae, is of trigonal form and has anterior, posterior and lateral sides. At the anterior side, tuberositas tibiae are seen a little lower than the condyli. The latter was fossil-

ized together with patella. The anterior side is concave at the outer end. Towards the distal epiphysis the corpus tibiae becomes thinner. The lower epiphysis broadens and forms the maleolus medialis. The tibia is considerably shorter than that in *Ch. borissiaki* but has greater diameters of epiphyses than other hyaenids.

Tarsus (Table 20)

The tarsus corresponds to the carpus of the fore limb but consists of seven bones: calcaneus, astragalus, cuboid,

Table 19
Measurements of the tibia (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
1. Maximal length	180	220	177.0
2. Transversal diameter at the proximal end	42	40.5	51.0
3. Antero-posterior diameter at the proximal end	34	39.5	50
4. Transversal diameter at the distal end	26	27.5	38.4
5. Antero-posterior diameter at the distal end	30	28.0	28.0
6. Transversal diameter at the narrowest part of diaphysis	18	15.5	16.0
7. Antero-posterior diameter at the narrowest part of diaphysis	17.5	–	–

Table 20
Measurements of the tarsus (mm)

	<i>A. eximia</i> Hadzhidimovo	<i>Ch. borissiaki</i> (Khomenko)	<i>Cr. crocuta</i> in Khomenko
1. Total length of the tuber calcanei	97.0	91.0	86.0
2. Maximal diameter at the joint of astragalus and calcaneus	32.0	31.0	–
3. Transversal diameter at the joint of naviculare and cuboideum	36.5	31.0	37.7
4. Transversal diameter at the joint of cuneiforme and cuboideum	40.0	29.5	37.0
5. Longitudinal diameter at the joint of cuboideum and naviculare	28.0	33.5	40.5
6. Total transversal diameter at the proximal end of ossa metatarsalia	38.5	–	–

naviculare, as well as three cuneiform bones, namely the endocuneiforme, mesocuneiforme and ectocuneiforme. All these bones articulate at their distal ends with the tibia, and at their proximal ends – with the metatarsals. The two bone rows in fore limb are not as pronounced here. Moreover, one can consider the presence of a third row due to the seventh bone. The latter is related to the highly atrophied first metatarsus, MT-I.

Calcaneus (Fig. 7. 3). It lies beneath the astragalus supporting the latter by sustentaculum tali. The posterior part is elongated and terminates with two tuberositas. The medial one is stronger. The plantar edge at the proximal end of this bone is considerably sharp. The described calcaneus is bigger than that in the other hyaenids. This is due to the longer posterior part. The anterior part that faces the cuboid is shorter.

Astragalus (Fig. 7. 4). All its components are well preserved – the head (caput), neck (collum), and body (corpus). There is a strong trochlea at the upper end for connection with the tibia. The trochlea is inclined in lateral direction and has three articulation surfaces. The head is robust. Its anterior surface is boat-like and connects it with the naviculare. The neck is wide and short. This makes the astragalus different from that in the living spotted hyaena and cave hyaenas. All tarsal bones here described are broader than those in the mentioned hyaenas (Orlov, 1939). Compared to *Ch. borissiaki*, the astragalus of our *A. eximia* is greater.

Naviculare. It lies over the head of astragalus. In proximal direction this bone is strongly concave, whereas in distal direction it is highly convex with two articulate surfaces for connection with the astragalus and cunei-

forms. The convexity of the fasseta for connection with the ectocuneiforme is the most pronounced. The anterior apophysis is elevated. On the external side there is a fasseta for connection with the cuboid.

Cuboid (Fig. 7. 5). Its proximal surface for connection with the calcaneus is completely flat. The distal fasseta connects this bone with the MT-IV and MT-V.

Cuneiformia (endo-, meso-, ectocuneiforme). The endocuneiforme is located in almost plantar position. This bone is high and laterally flattened. The proximal surface that connects it with the naviculare is convex upwards. On the fibular surface there are two equal fassetas – one for connection with the mesocuneiforme, and another, distal, for connection with MT-II.

The mesocuneiforme is shorter than the other cuneiformia. This bone is elevated by MT-II. The proximal surface connects it with the naviculare, and the distal surface – with MT-II. Both surfaces are concave.

The ectocuneiforme is the most robust bone among the cuneiformes. It has fassetas for connection with the cuboid, naviculare, mesocuneiforme, and MT-III. The dorsal surface looks sub-rhomboidal due to the oblique position of the distal and proximal fassetas.

Metatarsus (Fig. 7, Table 21)

All metatarsal bones are shorter than the corresponding metacarpal ones.

Metatarsus I. It is highly reduced. Only a small rudiment, 10 mm long, is seen.

Metatarsus II. The proximal surface for connection with the mesocuneiforme is oblique and elevated up to the mid

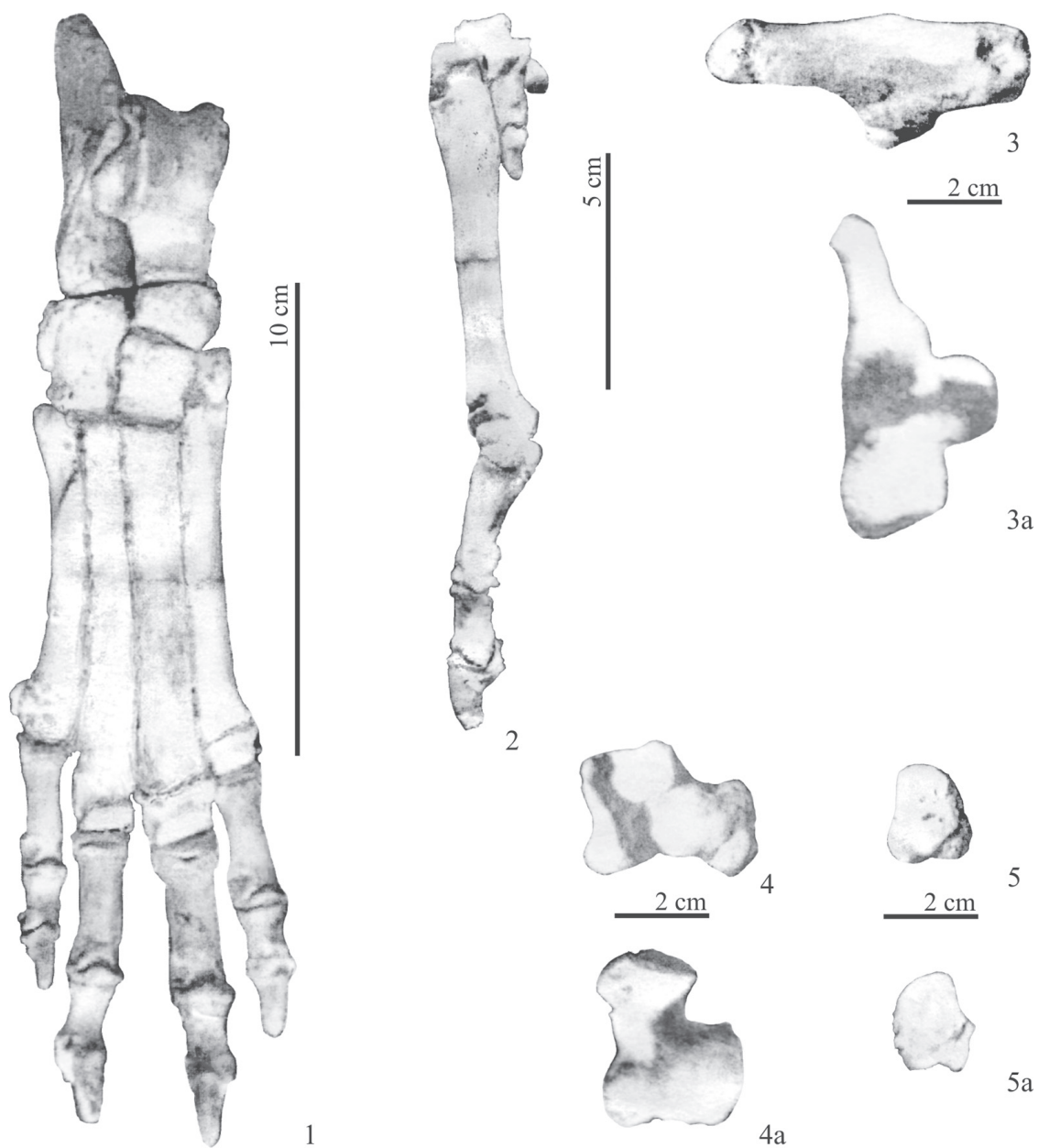


Fig. 7. Bones of the tarsus and metatarsus
 1. Metatarsus, view from above;
 2. Metatarsus, lateral view; the rudimentary finger is seen;
 3. Calcaneus, frontal view. 3a. Calcaneus, lateral view;
 4. Astragalus, view from above. 4a. Astragalus, view from below;
 5. Cuboid, frontal view. 5a. Cuboid, view from below.

Table 21
Measurements of the metatarsus (mm)

	Length	Antero-posterior diameter of head	Transversal diameter of head	Antero-posterior diameter at the distal end	Transversal diameter at the distal end
MT-I	–	10.0	–	8.0	–
MT-II	72.0	14.0	–	11.0	12.0
MT-3	82.0	21.0 and 22.5	14.0 and 15.0	–	15.5
MT-4	79.0	20.0	14.0	13.0	12.0
MT-5	66.0	~15.0	10.0	13.0	11.0

of ectocuneiforme. The location of the head is above the heads of MT-I and MT-III. The dorsal surface of trochlea is cylindrical in form. In plantar view, it is divided into two parts by a robust edge, like all metatarsal bones. The diaphysis, as well as the whole MT-III, is straight.

Metatarsus III. This is the longest and thickest metatarsal bone. Like the rest of metatarsalia, it is quite right. The proximal surface for connection with the endocuneiforme is oblique. The highest point of MT-III is at the level of the proximal fasseta of MT-IV. The trochlea is bigger than in the other metatarsal bones.

Metatarsus IV. It is as long as MT-III. The proximal surface connects the bone with the cuboid. A convexity on the plantar side is strongly manifested. There is a deep concavity on the fibular side for connection with MT-V. The body is straight. The trochlea is symmetrical.

Metatarsus V approaches MT-II in size. The fasseta for connection with the cuboid is inclined and concave. In the exterior part of this fasseta there is a distinct edge. It connects with the ligament of processus longus. The trochlea is inclined at the distal end.

Sesamoidal bones

These are small bones that occur between the distal ends of the metacarpal and metatarsal bones, on one side, and the proximal ends of the first phalanges, on the other side. Viewed from above, they look crescent-shaped, their tips pointing in dorsal direction. Viewed from below, they look like three-sided pyramids, their bases turning to the finger bones. Sesamoide bones occur in pairs. 12 pairs of the two fore limbs and 6 pairs of the hind limbs are found.

Phalanges (Table 22)

The phalanges of the hind limb are very close in their morphology to those of the fore limb but they differ in number. The first finger is vestigial.

The description, measurements and comparison of the fossil material suggest that the skeleton of Hadzhidimovo

Table 22

Measurements of the fingers of hind limb (mm)

Fingers	Length
f II-1	25
f II-2	14
f II-3	14
f III-1	30
f III-2	18
f III-3	16
f IV-1	25
f IV-2	14
f IV-3	–
f V-1	22
f V-2	14
f V-3	12

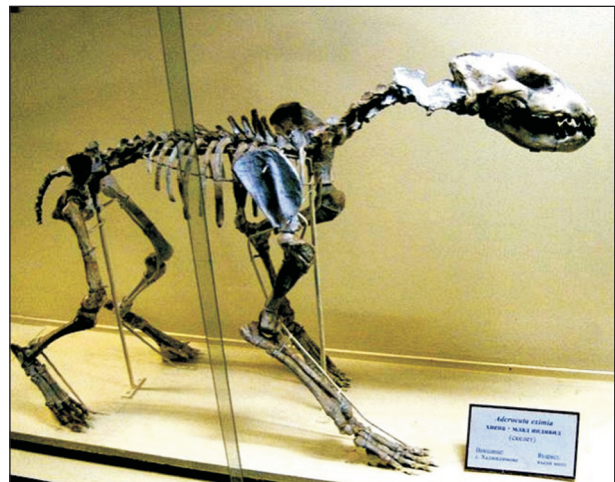


Fig. 8. The repaired skeleton of *Adcrocuta eximia* (Roth & Wagner) from Hadzhidimovo.

Table 23

Measurements of the repaired skeleton (mm)

1. Total length	1250
2. Height at the crest	610
3. Height at the pelvis	520
4. Width at the crest	200
5. Width at the pelvis	170

locality univocally belongs to *Adcrocuta eximia*. The repaired skeleton (Fig. 8, Table 23) is exhibited at the Asenovgrad Palaeontological Branch, National Natural History Museum of the Bulgarian Academy of Sciences.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION

Adcrocuta eximia was widely distributed in the Late Miocene (Turolian) of Eurasia. The species was a constituent of most famous and rich mammalian localities of that age from Spain to China (de Bonis, 2005). Turner et al. (2008) listed numerous localities of *A. eximia* in the Vallesian – Turolian (MN10 – MN 13) of Europe and Asia in the following countries: Bulgaria, FYROM, France, Greece, Hungary, Romania, Germany, Austria, Spain, Ukraine, Kazakhstan, Turkey, and Iran.

Koufos (2000, 2006, 2011), and Koufos et al. (2011) reported several localities of *A. eximia* in Greece. De Bonis et al. (1994) and de Bonis (2005) described the species from Turkey.

In Bulgaria, the localities of *A. eximia* are restricted to the Struma and Mesta River valleys in the southwestern part of the country. The species was found in Kalimantsi 2 and Kromidovo 2 localities (Spasov, 2002; Spasov et al., 2006) and was previously reported from

Hadzhidimovo locality by Spassov (2000). The present work represents a detailed description of a complete skeleton of *A. eximia*. Normally, only teeth, jaws, skull fragments or parts of bones were described. According to N. Spassov (pers. com.), the complete skeleton of *A. eximia* here described is unique of the entire Late Miocene in Eurasia.

Acknowledgements

The author expresses his gratitude to Prof. Nikolay Spassov (NMNH, Sofia) for providing him with literature on the topic of this paper. Editorial Board of the journal *Geologica Balcanica* kindly translated and edited this paper.

REFERENCES

- Andrews, C.W. 1918. Note of some fossil Mammals from Salonica and Imbros. *Geological Magazine* 6, 540–543.
- Barry, J.C. 1987. Large carnivores (Canidae, Hyaenidae, Felidae) from Laetoli. *Oxford Scientific Publication Clarendon Press*, 235–258.
- de Bonis, L. 2005. Carnivora (Mammalia) from the late Miocene of Akkaşdağı, Turkey. *Geodiversitas* 27(4), 567–588.
- de Bonis, L., Bouvain, G., Geraads, D., Koufos, G., Sen, S., Tassy, P. 1994. Les gisements de mammifères du Miocène supérieur de Kemiklitepe, Turquie. 11. Biochronologie, paléocologie et relations paléobiogéographiques. *Bulletin du Musée National d'Histoire Naturelle Paris, 4e série (C)* 16, 225–240.
- de Bonis, L., Koufos, G.D. 1981. A new hyaenid (Carnivora, Mammalia) in the Vallesian (Late Miocene) of Northern Greece. *Scientific Annals of the Faculty of Physics and Mathematics, University of Thessaloniki* 21, 79–94.
- de Bonis, L., Koufos, G.D. 1991. The Late Miocene small carnivores of the Lower Axios Valley (Macedonia, Greece). *Geobios* 24(2), 361–379.
- Boule, M., 1893. Description de l'*Hyaena brevirostris* du Pliocène de Sainzelles près de Le Puy (Haute-Loire). *Annales des sciences naturelles* 15 (série 8), 85–97.
- Chen, G., Schmidt-Kittler, N. 1983. The deciduous dentition of *Percrocuta Kretzoi* and the diphyletic origin of the Hyaenas (Carnivora, Mammalia). *Paläontologische Zeitschrift* 57, 159–169.
- Gaudry, A. 1862. *Animaux fossils et géologie de l'Attique*. Savy, Paris. Société Géologique de France, 476 pp.
- Ivanov, D. 1995. Palynological data on the fossil flora from the village of Ognjanovo, Southwestern Bulgaria. *Phytologia Balcanica* 1(2), 3–14.
- Ivanov, D., Utescher, J., Ashraf, R., Mossbrugger, V., Bozukov, V., Djorgova, N., Slavomirova, E. 2011. Late Miocene palaeoclimate and ecosystem dynamics in Southwestern Bulgaria – a study based on pollen data from the Gotse-Delchev Basin. *Turkish Journal of Earth Sciences* 21, 187–211.
- Khomenko, I.P. 1931. *Hyaena borissiakii* n.sp. from the Russillon fauna of Bessarabia. *Proceedings of the Paleontological Institute, Academy of Sciences USSR* 1, 81–126 (in Russian, German summary).
- Koufos, G.D. 1995. The late Miocene *Percrocutas* (Carnivora, Mammalia) of Macedonia, Greece. *Paleovertebrata* 24 (1–2), 67–84.
- Koufos, G.D. 2000. Revision of the late Miocene carnivores from the lower Axios Valley. *Münchener Geowissenschaften Abhandlungen (A)* 39, 51–92.
- Koufos, G.D. 2006. The Neogene mammal localities of Greece: Faunas, chronology and biostratigraphy. *Hellenic Journal of Geosciences* 41, 183–214.
- Koufos, G.D. 2011. The Miocene carnivore assemblages of Greece. *Estudio Geológicos* 67(2), 291–320.
- Koufos, G.D., Kostopoulos, D.S., Vlachou, T.D., Konidaris, G.E. 2011. A synopsis of the late Miocene mammal fauna of Samos Island, Aegean Sea, Greece. *Geobios* 44, 237–251.
- Kovachev, D. 2012. A porcupine skeleton of *Hystrix (Hystrix) primigenia* (Wagner, 1848) from the Upper Maeotian (Turolian) near Hadzhidimovo, south-western Bulgaria. *Geologica Balcanica* 41(1–3), 3–20.
- Kurtén, B. 1956. The status and affinities of *Hyaena sinensis* Owen and *Hyaena ultima* Matsumoto. *American Museum Novitates*, 1764, 1–48.
- Kurtén, B. 1957. *Percrocuta Kretzoi* (Carnivora, Mammalia), a group of Neogene hyenas. *Acta Zoologica Cracoviensia* 2, 375–404.
- Mecquenem, R. de. 1925. Contribution à l'étude des fossiles de Maragha. *Annales de Paléontologie* 13–14, 135–160, 1–36.
- Nenov, T., Stoyanov, I., Stoykov, S. 1972. The Pliocene and Quaternary in the Gotze Delchev Valley. *Review of the Bulgarian Geological Society* 32(2), 195–204 (in Bulgarian).
- Orlov, Y.A. 1939. Some data on the limb structure of *Crocuta*. *Proceedings of the Academy of Sciences USSR* 22(8), 538–540 (in Russian).
- Orlov, Y.A. 1941. Tertiary carnivores of Siberia. IV. Hyaenidae. *Proceedings of the Paleontological Institute* 8(3), 41–53 (in Russian).
- Pilgrim, G.E. 1931. *Catalogue of the Pontian carnivore of Europe in the Department of Geology, British Museum (Natural History)*, 1–174.
- Pilgrim, G.E. 1932. The fossil Carnivora of India. *Memoirs of the Geological Survey of India, New Series* 28(1), 1–232.
- Reynolds, S. 1902. A monograph of the British Pleistocene Mammalia. Volume II, Part II. The Cave Hyaena. *Paleontological Society Monographs* 1902, 1–25.
- Schmidt-Kittler, N. 1976. Raubtiere aus dem Jungtertiäre Kleinasien. *Paleontographica A* 155, 1–131.
- Simeonescu, I. 1930. Vertebratele Pliocene dela Malusteni (Covurlui). *Academia Romana – Publicatiunile Adamachi* 9, 83–148.
- Spassov, N. 2000. The Turolian *Hipparion* fauna and the character of the environment in the Late Miocene of West Bulgaria. *Review Bulgarian Geological Society* 61(1–3), 47–59.
- Spassov, N. 2002. The Turolian megafauna of West Bulgaria and the character of the Late Miocene “Pikermian biome”. *Bollettino della Società Paleontologica Italiana* 41(1), 69–81.
- Spassov, N., Tzankov, Tz., Geraads, D. 2006. Late Neogene stratigraphy, biochronology, faunal diversity and envi-

- ronments of South-West Bulgaria (Struma river valley). *Geodiversitas* 28(3), 417–441.
- Stoyanov, I., Nenov, T., Stoykov, S. 1974. Geological structure and tectonic development of the Mesta graben. *Annual of Sofia University, Faculty of Geology and Geography* 66, Series 1, Geology, 85–100 (in Bulgarian).
- Temniskova-Topalova, D., Ognjanova-Rumenova, N. 1983. Diatom fossils from fresh-water Neogene diatomites in the Gotse Delchev region. *Fitologia* 22, 29–45.
- Turner, A., Anton, M., Werdelin, L. 2008. Taxonomy and evolutionary patterns in the fossil Hyaenidae of Europe. *Geobios* 41(5), 677–687.
- Vatsev, M. 1980. Lithostratigraphy of the Neogene sedimentary rocks of the Gotse Delchev Basin. *Annual of the University of Mining and Geology* 25(2), 103–115 (in Bulgarian).
- Vatsev, M., Petkova, A. 1996. New data about the stratigraphy of the Neogene in Gotse Delchev Basin. *Annual of the University of Mining and Geology* 41(1), 13–20 (in Bulgarian with English abstract).
- Werdelin, L., Solounias, N. 1990. Studies of fossil hyaenids: the genus *Adcrocuta* Kretzoi and the interrelationships with some hyaenid taxa. *Zoological Journal of the Linnean Society* 98, 363–386.
- Yaneva, M., Ognjanova, N., Nikolov, G. 2002. Palaeoecological development of the Gotse Delchev Basin during the Neogene, South-west Bulgaria. *Proceedings International Scientific Conference in Memory of Prof. Dimitar Jaranov, Varna 2002*, 36–47 (in Bulgarian with English abstract).
- Zdansky, O. 1924. Jungtertiäre Carnivoren Chinas. *Paleontologia Sinica, ser. C* 2(1), 1–149.