

Otis hellenica sp. nov., a new Turolian bustard (Aves: Otididae) from Kryopigi (Chalkidiki, Greece)

Zlatozar Boev¹, Georgios Lazaridis², Evangelia Tsoukala²

¹National Museum of Natural History, Bulgarian Academy of Sciences, 1 Blvd. Tsar Osvoboditel, 1000 Sofia, Bulgaria; e-mail: boev@nmnhs.com;

²School of Geology, Aristotle University, 54124 Thessaloniki, Greece; e-mails: geolaz@math.auth.gr, lilits@geo.auth.gr

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Abstract. Two pedal phalanges (ph. 1 dig. 3 sin. and ph. 3 dig. 3 dex.) are referred to *Otis hellenica* sp. nov., larger than the recent *Otis tarda* with estimated body weight of ca. 19 kg. Kryopigi is a new, the sixth avian Neogene locality of Greece. The finds represent the first Neogene record of bustards in the country and their first Miocene record on the Balkan Peninsula.

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Key words: Fossil birds, Bustards, Late Miocene, Greece, Turolian fauna.

INTRODUCTION

The Kryopigi locality of fossil vertebrate fauna is located at the northern part of the Kassandra Peninsula of Chalkidiki, northern Greece, and has been excavated since 1998 by the team from Aristotle University, School of Geology, lead by E. Tsoukala. The bulk of the finds belongs to mammals (over 7 000 specimens of 26 species including birds and reptiles). The preliminary list of the fauna is given by Lazaridis, Tsoukala (2014 a). The Kryopigi hipparions (Lazaridis, Tsoukala, 2014 b) and *Mesopithecus pentelicus* (Tsoukala, Bartsiakos, 2008) date the locality of the late half of the Turolian. The avian finds collected in the Kryopigi faunal assemblage is described in the present paper.

MATERIAL AND METHODS

The KRY 1300 bone specimen represents a pedal phalanx – phalanx 1 dig. 3 sin. (Fig. 1), while the KRY 1807 is a phalanx 3 dig. 3 dex. (Fig. 2).

The osteological terminology follows Livezey, Zusi (2006).

Abbreviations: National Museum of Natural History,

Bulgarian Academy of Sciences – NMNHS; Paleontological Institute, Russian Academy of Sciences – PIN.

SYSTEMATIC PALEONTOLOGY

Class AVES Linnaeus, 1758

Order GRUIFORMES Bonaparte, 185

Family OTIDIDAE Rafinesque, 1815

Otis Linnaeus, 1758

***Otis hellenica* sp. nov.**

Figs 1, 2.

Measurements. The manner of measuring is given in Fig. 3; the measurements are given in Tables 1 and 2. The measurements “d” and “g” are minimal height and minimal thickness of the phalangeal body, respectively.

Etymology. The name “*hellenica*” derives from Hellas – the ancient name of Greece, the country, where the finds originate from.

Type material. Holotype: pedal phalanx – phalanx 1 dig. 3 sin., KRY 1300 (Fig. 1). It is almost complete and only the dorsal half of the medial condyle of the trochlea articularis and a fourth of the edge of facies

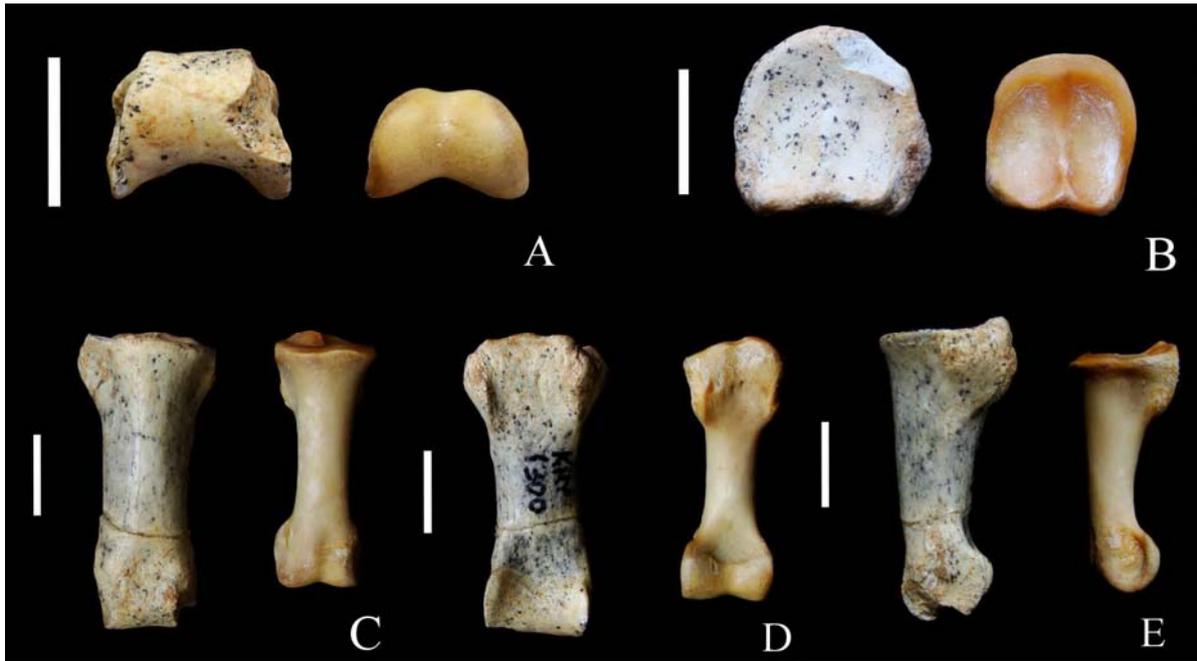


Fig. 1. *Otis hellenica* sp. nov. (left: holotype – KRY 1300) and *Otis tarda* (right), phalanx 1 dig. 3 sin.: cranial view (A), caudal view (B), dorsal view (C), ventral view (D), left lateral view (E). Scale bar = 1 cm. Photographs: Assen Ignatov.

articularis proximalis are damaged. The material was collected in 1998 and it is stored in the Aristotle University, School of Geology, Thessaloniki, Greece.

Paratype. phalanx 3 dig. 3 dex., KRY 1807 (Fig. 2, Table 2).

Type locality. Kryopigi, Kassandra Peninsula, Chalkidiki, Macedonia, northern Greece.

Stratigraphic and geographic range. Middle-Late Turolian, MN12-13 (late Miocene), Southeast Europe.

Material. ph. 1 dig. 3 sin. (holotype) and ph. 3 dig. 3 dex. (paratype).

Diagnosis. Similar to recent *O. tarda*, but larger (phalanx 1 dig. 3 is 15 to 34%), longer and more robust (37 to 58% thicker in the middle); differs by the less concave facies articularis proximalis, less asymmetric phalangeal body, almost symmetrical ventral end of proximal articular surface and the shallower fovea under the distal articular surface. Phalanx 3 dig. 3 also larger and more robust. It is 50 to 60% longer and 38 to 53% thicker in the middle.

Comparative material. The Kryopigi material has been compared to the fossil and recent material stored in the Natural Museum of Natural History, Sofia (NMNHS) and specimens of the collection of the Paleontological Institute, Russian Academy of Sciences, Moscow. Fossil material: Otididae gen. PIN 3381-426; Recent material: *Otis tarda* Linnaeus, 1758: NMNHS 3/2014, NMNHS 2/2014, PIN 65-2-1; *Ardeotis kori* (Burchell, 1822): PIN 65-9-1; *Chlamydotis undulata* (Jacquin, 1784): PIN 65-12-1, PIN 65-12-2; *Tetrax tetrax* (Linnaeus, 1758): NMNHS 1/1986 – Azerbaijan, PIN

65-1-1 – Azerbaijan, PIN 65-1-4 – Lower Volga, Russia (probably captive); *Grus grus* (Linnaeus, 1758): NMNHS 2/1992 – Spain; *Anthropoides virgo* (Linnaeus, 1758): NMNHS 1/1989 – Gobi, Inner Mongolia, China.

Description and Comparison. This phalanx is the largest pedal phalanx in the skeleton of avian foot. The corresponding phalanges of family Gruidae (*Grus grus* and *Anthropoides virgo* compared) are much more elongated and gracile and proportionally completely exclude a taxonomic affiliation. They are clearly distinguished by the family Otididae (Fig. 4).

The general morphology and dimensions of the studied material (Table 1) suggest a species of Otididae. Morphologically and dimensionally the find could be referred to the largest species of genus *Otis*. It clearly fits bustard's phalanx 1 dig. 3 by its high proximal epiphysis and powerful ventrally curved hillock, as it has been noted by Kuročkin (1985).

Dimensionally it approaches the modern *O. tarda* (largest male specimens) (Table 1) but in morphology differs from the great bustard by the less concave facies articularis proximalis and general lesser asymmetry of the phalangeal body. The find KRY 1300 bears the specific features for bustards, i.e. robustness, large (high) cotyla articularis, short phalangeal body and well developed trochlea articularis. The same are the features of the find KRY 1807.

KRY 1300 resembles *O. tarda* very much, but its clear robustness must be mentioned. Although the

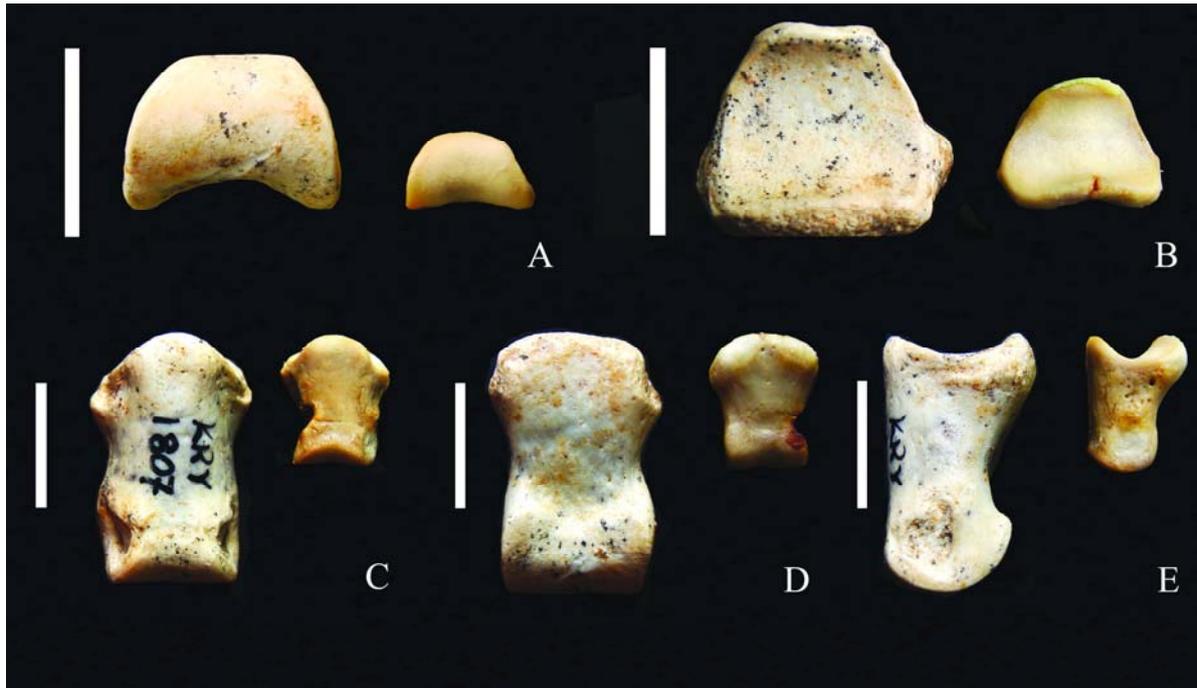


Fig. 2. *Otis hellenica* sp. nov. (left: paratype – KRY 1807) and *Otis tarda* (right), phalanx 3 dig. 3 dex.: cranial view (A), caudal view (B), dorsal view (C), ventral view (D), left lateral view (E). Scale bar = 1 cm. Photographs: Assen Ignatov.

sexual dimorphism in bustards is very expressive in body size (including pedal phalanges), because of the considerable size differences, we could exclude of our considerations the genera *Tetrax*, *Chlamydotis* and *Gryzaja*. After data on the length (means) of the 3rd toe of foot of *O. tarda* (Cramp, Simmons, 1980), the males exceed the females of ca. 19.7%. Considerable are the differences in the sexes of other large Palearctic species – the Arab bustard (*Ardeotis arabs* (Linnaeus, 1758)) – 6.3%. In the largest bustard species (genera *Otis* and *Ardeotis*), females “reach roughly two thirds the height and one third the weight of the males” (Collar, 1996). It is worthy to mention, that the Kryopigi specimen exceeds (measurement “a”) the compared specimen of modern (males) *O. tarda* almost twice – of 34.2%, enough to exclude the taxonomic identity besides the considerable chronostratigraphic difference of ca. 8 Ma.

The other find, phalanx 3 dig. 3 dex., also fits both the shape and the proportions of *O. tarda*, but considerably exceeds it by its dimensions.

DISCUSSION AND CONCLUSIONS

Recent bustards

After Collar (1996), a total of 25 recent species are listed in the family Otididae from Eurasia, Africa and Australia. The three modern species of the European avifauna are known only from the Pliocene: *Chlamydotis undulata* Jacquin, 1784 from the Late

Pliocene (MN 16) of Beremend 15, Hungary, *Tetrax tetrax* (Linnaeus, 1758) from the Late Pliocene (MN 16) of Etulia, Moldova, and *Otis tarda* Linnaeus, 1758 from the Early Pliocene (MN 14) of Vojničevo, Ukraine.

Fossil bustards

A number of Neogene bustards have been described so far from Europe (Mlíkovský, 2002): (1) *Miootis compactus* Umans'ka, 1979 (holotype – carpometacarpus), Late Miocene (MN 13) of Nova Emetivka, Ukraine. After Mlíkovský (2002) the taxonomic identity of this genus and species requires confirmation. (2) *Chlamydotis affinis* (Lydekker, 1891) (holotype – “crushed postcranial skeleton in slab”, Middle Miocene (MN 7) of Steinheim, Germany. (3) *Chlamydotis mesetaria* Sánchez Marco, 1990 (holotype – right tibiotarsus), Early Pliocene (MN 15) of Layna, Spain; (4) *Otis bessarabensis* Kessler & Gál, 1996 (holotype – distal ulna), Late Miocene (MN 9) of Chişinău, Moldova. After Mlíkovský (2002) the taxonomic identity of this species needs confirmation; (5) *Gryzaja odessana* Zubareva, 1939 (lectotype – distal end of tibiotarsus), Early Pliocene (MN 15) of Odessa catacombs, Ukraine.

In addition, Burchak-Abramovich, Vekua (1981) described a new genus and species *Ioriotis gabunii* of “Middle-Akchagylia”, i.e. late Pliocene deposits near Kvavebi village (East Georgia). Those authors stated it was considerably larger than any recent species of Otididae Gray, 1840 (estimations of 1/3 larger than recent male *O. tarda*). It also was a (almost) flightless

Table 1

Measurements of the phalanx 1 dig. 3 in fossil and recent large gruiforms (referred to Fig. 2)

Species	a	b	c	d	e	f	g
Fossil							
<i>Otis hellenica</i> sp. nov. KRY 1300 – Kryopigi, Greece	33.47	10.12	14.97	7.22	11.83	15.74	9.43
Recent							
<i>Otis tarda</i> ♂ ad. NMNHS 3/2014 Bulgaria	28.43	7.46	12.98	5.39	10.58	11.91	5.94
<i>Otis tarda</i> ♀ ad. NMNHS 2/2014 Bulgaria	22.03	4.88	9.41	3.24	6.77	8.09	3.92
<i>Otis tarda</i> PIN 65-2 Eastern Gobi, Mongolia	27.4	6.2	11.9	4.8	8.7	10.7	5.4
<i>Ardeotis kori</i> PIN 65-9-1 no locality data	29.8	7.2	13	4.9	9.6	11.4	6.2
<i>Chlamydotis undulata</i> PIN 65-12-1 Kazakhstan	15.2	3.7	6.6	2.4	5.3	6.0	3.0
<i>Chlamydotis undulata</i> PIN 65-12-2 Turkmenistan	15	3.7	6.2	2.3	5.0	5.3	2.9
<i>Tetrax tetrax</i> NMNHS 1/1986 Azerbaijan	13.27	2.98	4.92	2.13	3.80	4.35	2.54
<i>Tetrax tetrax</i> PIN 65-1-1 Azerbaijan	13.2	2.9	5.0	2.0	3.3	4.1	2.3
<i>Tetrax tetrax</i> PIN 65-1-4 Lower Volga, Russia (probably captive)	13.3	2.9	5.1	1.9	3.3	4.1	2.2
<i>Grus grus</i> NMNHS 2/1992 Spain	36.22	6.59	10.38	4.12	6.45	9.43	4.93
<i>Anthropoides virgo</i> NMNHS 1/1989 Gobi - Inner Mongolia, China	28.81	5.67	9.04	3.39	5.54	7.63	4.38-

and fast runner. The only material found is the holotype of a proximal end of left humerus. The morphological features of its proximal humeral bone place it closer to the genus *Tetrax* T. Forster, 1817 instead to *Otis*. The type locality of *I. gabunii* is removed from the type locality of *O. hellenica* sp. nov. at ca. 1300 km. The geochronological difference is ca. 5 Ma, as the Kvabebi locality in Eastern Georgia is dated Middle-Akchagylian, i.e. Late Pliocene (Piacenzian).

Two late Pliocene bustards of Southern Moldova have been synonymized as follows: *Otis khosatzkii* Bocheński & Kuročkin, 1987 to *Chlamydotis undulata* Jacquin, 1784, and *Otis paratetrax* Bocheński & Kuročkin, 1987 to *Tetrax tetrax* (Linnaeus, 1758) (Mlíkovský, 2002).

Kuročkin (1985) described a phalanx 1 dig. 3 (the same skeletal element as the Kryopigi specimen) of Otidae gen. indet. from the Chikoyan Suite, Upper Pliocene of Shamar locality, Selenga Aymak in Northern Mongolia. The author's statement is that the species is a little larger than modern *Chlamydotis undulata*. It differs from the recent *Otis*, *Chlamydotis* and *Choriotis* (i.e. *Ardeotis*) by its almost symmetrical ventral end of proximal articular surface and the smaller fovea under the distal articular surface. Surprisingly,

both mentioned features are well presented in the Kryopigi bustard.

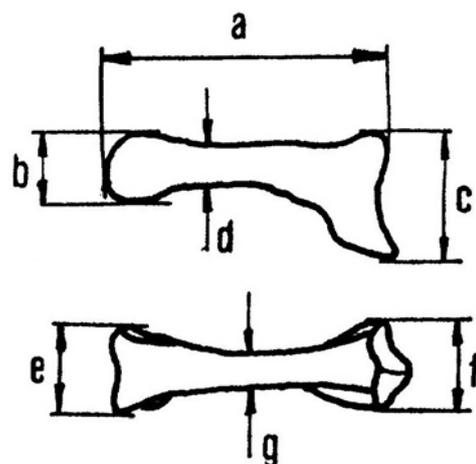


Fig. 3. Manner of measuring of the pedal phalanges in fossil and recent large gruiforms. Drawing: Vera Hristova.

Table 2

Measurements of the phalanx 3 dig. 3 in fossil and recent large gruiforms (referred to Fig. 3)

Species	a	b	c	d	e	f	g
Fossil							
<i>Otis hellenica</i> sp. nov. KRY 1807 – Kryopigi, Greece	20.73	8.36	11.24	6.77	11.16	13.40	10.08
Recent							
<i>Otis tarda</i> ♂ ad. NMNHS 3/2014 Bulgaria	10.49	3.96	6.55	3.99	6.38	8.66	ca. 6.24
<i>Otis tarda</i> ♀ ad. NMNHS 2/2014 Bulgaria	8.18	3.14	4.59	2.80	5.20	5.94	4.67
<i>Tetrax tetrax</i> NMNHS 1/1986 Azerbaijan	5.31	1.82	2.92	1.75	2.22	2.81	2.13
<i>Grus grus</i> NMNHS 2/1992 Spain	12.87	3.07	4.83	3.62	4.04	5.17	3.49

The Kryopigi specimen could not be referred to any of the listed fossil and recent bustards known so far.

Undoubtedly, “Being birds of arid habitats, the bustards have left very few fossils and the extant species may represent a relatively recent radiation” (del Hoyo et al., 2013). Neogene bustards have not been known so far from the Balkan Peninsula. Kryopigi is the sixth avian Neogene locality of Greece. Mlíkovský (1996) listed three Neogene avian localities: (1) Samos, (2) Pikermi, and (3) Aegina. In addition, Boev, Koufos (2000) reported (4) Megalo Emvolon, and Boev, Koufos (2006) – (5) Perivolaki fossil sites.

The family Otididae was not recorded so far in the Neogene of Greece and the Kryopigi provides first proof of the former distribution of large bustards (and the bustards at all) in the late Miocene of the country. The presence of bustards may suggest large open grassy habitats of plain landscape in the region of the locality,

which completely corresponds to other large terrestrial faunal elements (large mammals and first of all, ungulates). The presence of bustards also corresponds to the records of *Struthio karatheodoris* from Greece – Pikermi (Forsyth Major, 1888), and Samos (Martin, 1903), and Southwest Bulgaria – Kalimantsi and Hadzhidimovo (Boev, Spassov, 2009), to the records of ground hornbills in Hadzhidimovo (Boev, Kovachev 2007), and these of Snakeeagles (Boev, 2012), a suggestion for the existence of the former Greco-Iranian paleozoogeographic province in the Late Miocene. The Bulgarian finds from Varshets (Western Stara Planina Mountain; Boev, 1999) are much younger and recently the deposits of this Middle Villafranchian locality have been referred to the Early Pleistocene (~2.5 Ma). The find of Kryopigi is the first record of bustards in the Neogene of Greece and their first Miocene record on the Balkan Peninsula.

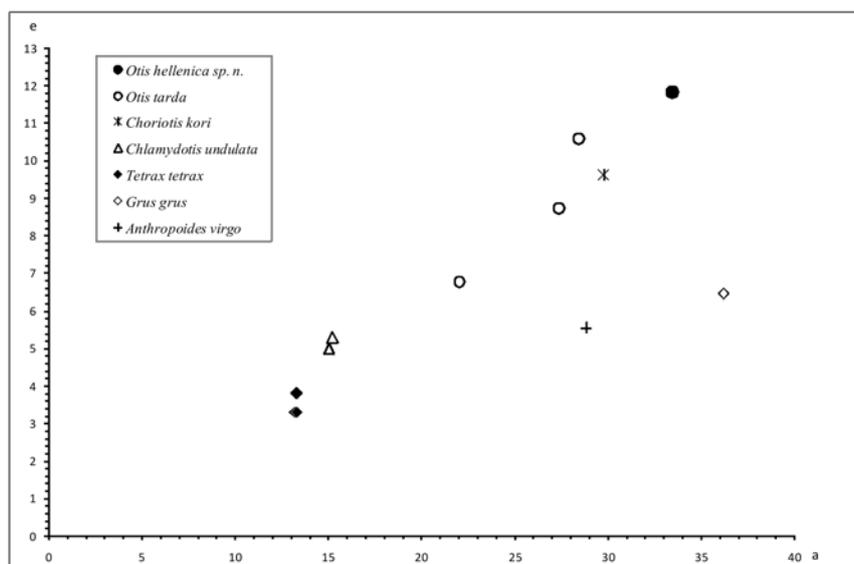


Fig. 4. Scatter diagram (in mm) of some fossil and recent large gruiforms in connection to the width of distal articular surface (e) and the total length (a) of the phalanx 1 dig. 3 pedis.

After Cramp, Simmons (1980) the body weight of the larger male individuals of *O. tarda* reaches up to 18 kg. After Collar (1996) males of *Ardeotis kori* (Burchell, 1822) reach 19 kg. On the other side, after Roots (2006) some adult males of *O. tarda* reaching a weight of 21 kg and wing span of 2.1 m, and the wild turkey (*Meleagris gallopavo* Linnaeus, 1758), reaching 15 to 16.8 kg, are the heavier flying modern birds. That author stated that the size barrier of 16.8 kg is the load limit for modern flying birds. He also summarized that “The bustards, wild turkeys, pelicans, condors, swans, and albatrosses are the largest living flying birds, with the maximum flying weight in modern birds being ...21 kg of body weight, which is reached in the great bustard (*Otis tarda*)” (p. 4). The Miocene large bird, *Pelagornis chilensis* Mayr, Rubilar-Rogers, 2010, had body mass of 16–29 kg, which is “moderately above [the] range of large extant volant birds” (p. 1313) (Mayr, Rubilar-Rogers, 2010). Surprisingly, Palmqvist, Vizcaino (2003) stated that the gigantic condor-like Miocene *Argentavis magnificens* Campbell & Tonni 1980 was capable for flapping flight, besides its weight of 80 kg.

According to Dunning (2008), *O. tarda* is the heaviest recent bustard. Mean weight of males is 11.975 kg, of females – 3.816 kg. As the pedal phalanges of *O. hellenica* sp. nov. are of 15 to 50% larger than recent *O. tarda*, it is obviously that the body weight of the fossil bustard of Kryopigi was at least (average) ~ 30% larger than that of the *O. tarda* (ca. 3.3-18.0 kg after data of Collar (1996) and 3.3-16.0 kg after data of Cramp, Simmons (1980). As one of the compared specimens of *O. tarda* (NMNHS 3/2014) is an adult and very large individual (over 12 kg), we could estimate that the body weight of the examined specimen of Kryopigi is at least 18.920 kg (14.127 kg according phalanx 1 dig. 3, and 23.714 kg according phalanx 3 dig. 3). Thus, *O. hellenica* sp. nov. could be a savanna runner, and the probability of the species’ flightlessness is significant. Even more, while the phalanx 1 dig. 3 is longer of 15% than that of *O. tarda*, the more distally positioned pedal phalanx, phalanx 3 dig. 3, is longer 50%. This is a clear indication of more “pedal-like” (i.e. terrestrial ground) mood of movement. Relative elongation of more distal pedal phalanx can support the body weight better in the walking or running on the ground. The find KRY 1807 surprisingly resembles both in shape and proportions to the analogous pedal phalanx of the recent Ostrich (*Struthio camelus* Linnaeus, 1758), a case of morphological convergence. This once again supports the suggestion of the separating of the Kryopigi fossils in a distinct new species morphologically differing from *O. tarda*.

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