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Ornis Hungarica 2024. 32(1): 222–230.
DOI: 10.2478/orhu-2024-0016

Phalacrocorax bakonyiensis n. sp., a new species of cormorant from the Late Miocene of Hungary

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Received: October 17, 2023 – Revised: April 29, 2023 – Accepted: May 06, 2024

Horváth, I., Futó, J. & Kessler, E. J. 2023. *Phalacrocorax bakonyiensis* n. sp., a new species of cormorant from the Late Miocene of Hungary. – Ornis Hungarica 32(1): 222–230. DOI: 10.2478/orhu-2024-0016

Abstract We describe *Phalacrocorax bakonyiensis* n. sp. an extinct member of the cormorants (Phalacrocoracidae). The fossil was found in 2021 by geologist János Futó in the sediments of a small cave cavity on the side of Várhegy in Sümeg, a part of the Bakony Mountains of West Hungary, where Late Miocene (MN11–12) vertebrate fossils have been found in the past decades. The total number of bone fragments collected was 14, of which only three can be identified. Two of these belong to adults and one, due to its poor preservation and size, to a very young specimen.

Keywords: West Hungary, Sümeg, Várhegy cave no. 2., Late Miocene, cormoran

Összefoglalás A kormoránfélék (Phalacrocoracidae) egy kihalt képviselőjét, a *Phalacrocorax bakonyiensis* n. sp.-t mutatjuk be. A leletre a Ny-Magyarországi Bakony-hegységhez tartozó Sümegről, a sümegi Várhegy oldalán lévő kis barlangüreg üledékében talált rá Futó János geológus 2021-ben, ahonnan már korábban is kerültek elő késő-miocén korú (MN11–12) gerinces fosszíliák az elmúlt évtizedekben. Összesen 14 csonttöredéket sikerült begyűjteni, melyek közül csupán három azonosítható. Ebből kettő kifejlett egyedhez tartozik, egy pedig elmosódott jellege és mérete miatt egy nagyon fiatal példányhoz.

Kulcsszavak: Nyugat-Magyarország, Sümeg, Várhegy 2 sz. barlang, késő-miocén, kárókatona

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Introduction

In 1991, cave explorers from Veszprém collected several bird bones from the sandy sediment of cave No. 2 of Várhegy in Sümeg, at a depth of 2 m, which were brought to the Natural History Museum of Hungary for the paleontologist Dénes Jánossy. Preliminary examination revealed that they were dealing with Late Miocene fossil *Phalacrocorax* finds, which included several specimens of different ages. Unfortunately, the material was not further identified, Dénes Jánossy retired in 1997 and died in 2005, and the material was lost when the Museum moved to its new building in 2003.

In 2021, the geologist János Futó visited the cave and managed to collect 14 bone fragments from the remaining sediment and bring them to us. Three of these specimens proved to be

identifiable, and two of them, similar to the 1991 finds, were found to be skeletal parts of a cormorant species of smaller size than the great cormorant, of a size intermediate between the extant *Phalacrocorax auritus* and *Microcarbo pygmaeus*.

More recently, the little cormorant is classified in the genus Microcarbo (formerly *Phalacrocorax pygmaeus*) (Worthy 2011).

Geological and geomorphological environment

The Cretaceous Tatai Limestone, on which late Miocene (Pannonian) abrasion conglomerate was cemented in the mountain lobe zone (Haas *et al.* 1984), forms the insular structure of the hill of Vár, which rises about 50 m above the surrounding area. The original site is the shaft-like cave (Schäfer *et al.* 1995), located at 250 m above sea level on the southern edge of the hill's roof. In the immediate vicinity, the remains of several fossil spring channels with a karst thickness are still visible in the limestone. The sediment, completely excavated from the cave, was deposited on the steep slope in front of the cave mouth during excavation. This has been largely washed away by the rains since then, but there may still be further bone fragments in the remains.

The evolutionary history of the former archaeo-geographical setting can be reconstructed as follows (unfortunately, no detailed analysis of the stratigraphy of the excavated sediment fill was made during the excavation of the cave, and only minimal material remains in the cavity).

Lake Pannon gradually flooded the island cone of the Castle Hill and covered it with clay and sand as a result of the general rise in water levels in the Carpathian Basin 10 million years ago. In the meantime, the upwelling paleo-karstic waters have created a cavity a few metres deep, at the bottom of which half a metre of coarse-grained sand mixed with rock silt was washed in from the surrounding terrain. At this point, bird bones may have been deposited, and after a pause in sedimentation, another two metres of rock chippings almost completely filled the shaft. At this stage, the area was probably already dominated by the river plain that had replaced Lake Pannon. During the subsequent tectonic uplift of the region, which continues to this day, all the correlative sediments from Castle Hill were eroded away, with the exception of the material preserved in the cave.

Background

The early members of this distinctively fish-eating bird family belong to the subfamily Graculavinae and are known from the North American Palaeocene with two species of *Graculavis* (*G. velox* Marsh 1872 and *G. pumilus* Marsh 1872) (Brodkorb 1963). The earliest member of the subfamily Phalacrocoracinae, which includes extant cormorant species, is known from the Eocene in England (*Actiornis anglicus* Lydekker, 1891) (Brodkorb 1963), based on the proximal epiphysis of an *ulna*. The *Actiornis anglicus* fossil was described in the Phalacrocoracidae (Harrison & Walker (1976a)). They transferred it to the Threskiornithidae. But Olson (1981) observed that its holotype is neither from a cormorant, nor from an ibis. Mlíkovský placed this specimen in the category Aves incertae sedis.

Another specimen from this period, also from England (MP17) (Mlíkovský 2002), was described on the basis of an incomplete upper beak fragment, described by Harrison and Walker (1976b) as *Piscator tenuirostris*, but Mlíkovský also placed this specimen too in the category Aves incertae sedis, thus suggesting that the affinities of the taxon are questionable.

The genus *Phalacrocorax* was first indicated from the Early-Middle Oligocene of North America (USA) by Shufeldt through the proximal end of a metacarpal bone (*Phalacrocorax mediterraneus* Shufeldt, 1915) (Brodkorb 1963). It was indicated from the Early-Middle Oligocene from the Jebel Qatrani Formation, Fayum, Egypt, based on a characteristic beak remains (Rasmussen *et al*. 1987) and from the Late Oligocene (MP30) several representatives of the *Borocarbo* genus from France and Germany (Mayr 2001, 2007, 2009, Mourer-Chauviré *et al*. 2004, Göhlich & Mourer-Chauviré 2010), *Praecarbo strigoniensis* Kessler & Horváth, 2023, from the Late Oligocene of Hungary (MP25–30), (Kessler & Horváth 2023). The other known species have all been described from the Neogene as *Oligocorax littoralis* (Milne-Edwards 1863) and *P. intermedius* (Milne-Edwards, 1867) from the Early and Middle Miocene (MN3–4 and MN7–8) of France, Germany, and the Czech Republic (Milne-Edwards 1863, 1867, Cheneval 1984, Mlíkovskỳ, 2002), and *P. ibericus* Villalta, 1963 from the Late Miocene of Spain (MN9), *P. lautus* Kurochkin & Ganea, 1972 from the Late Miocene of Moldova (MN9), *P. longipes* (Tugarinov, 1940) from the Late Miocene of Ukraine (MN11–13) and *P. serdicensis* Burchak-Abramovic & Nikolov, 1984 from the Late Miocene of Bulgaria (MN13–14) (Tugarinov 1940, Villalta 1963, Kurochkin & Ganea 1972, Burchak-Abramovic & Nikolov 1984, Mlíkovskỳ 2002). Of the later Middle and Late Miocene finds, only the Bulgarian one shows a proximal epiphysis of the *humerus* (*P. serdicensis* Burchak-Abramovic & Nikolov, 1984), but much larger than that of Sümegi (*P. aristotelis* size). *P. serdicensis* and *P. aristotelis* are considered to be the same size (Göhlich 2002). In addition to the above, several fossil species have been described from the Neogene of other continents (Asia, America, Australia) (Watanabe *et al.* 2018). *Nectornis miocaenus* is also relevant. In their paper, Göhlic and Mourer-Chauviré (2010) discuss several late Miocene cormorant species (such as *Phalacrocorax ibericus* Villalta, 1963 from Spain; *Phalacrocorax lautus* Kurochkin & Ganea, 1972 from Moldova; *Phalacrocorax serdicensis* Burchak-Abramovic & Nikolov, 1984 from Bulgaria; *Phalacrocorax longipes* (Tugarinov, 1940) from Ukraine), however, no size tables are given in the article. All of these species are much larger species than the *P. bakonyiensis* we are presenting.

Material and Method

Three of the 14 bone fragments collected were identified: a left *humerus* proximal epiphysis *(Figure 1/1–2)*, a small juvenile *humerus* proximal epiphysis *(Figure 2/1–2)* and a fragment of an incomplete left *humerus* diaphysis *(Figure 2/3–4)*. To identify morphological features, we used the handbook of Baumel *et al*. 1979. The method of measurement was adapted from Kessler 2013. The finding was compared with *humerus* of extant species. We used the corresponding bone of a Great Cormorant *(Phalacrocorax carbo) (Figure 1/3–4, 2/5–6)* and Pygmy Cormorant *(Microcarbo pygmeus) (Figure 1/5–6, 2/7–8)*.

Concerning size, we would like to emphasize that we have not found in the literature any data on small cormorant *humerus* that could serve as a basis for our comparison. All the data we know are either from significantly larger species or from much earlier finds.

Abbreviations: C-width of proximal epiphysis; C1-width of *caput humeri*; E-thickness of *diaphysis*; a. *caput humeri;* b. *incisura capitis;* c. *tuberculum dorsale;* d. *sulcus lig. transversus;* e. *impressio coracobrachialis;* f. *intumescentia humeri;* g. *crista delto pectoralis;* h. medal view of *incisura capiti;* i. *tuberculum ventrale;* j. *fossa pneumotricipitalis;* k. *crista bicipitalis;* l. *margo caudalis*.

Systematics

Class Aves Linnaeus, 1758
Order Pelecaniformes Sharpe, 1891
Family Phalacrocoracidae (Reichenbach, 1849)
Subfamily Phalacrocoracinae (Reichenbach, 1849)
Genus: *Phalacrocorax* Brisson, 1760
Species: *Phalacrocorax bakonyiensis* n. sp.

Site and age: Sümeg, Várhegy Cave No. 2. (Veszprém county, Veszprém district, Hungary), Late Miocene (MN11–12).

Materials: left *humerus*, proximal epiphysis (holotype) *(Figure 1/1–2*); a small juvenile *humerus* proximal epiphysis *(Figure 2/1–2)*; *humerus* diaphysis fragment *(Figure 2/3–4)*; diaphysis fragment (paratype) *(Figure 1/3–6)*; a small juvenile *humerus*, proximal epiphysis (paratype). Material not yet catalogued.

Dimensions (in mm): *P. bakonyiensis n.* sp.: C-22.54, C1-10.84

Dimensions of comparative materials (in mm): *Phalacrocorax carbo* (Linnaeus, 1753) C-24.22–27.00, C1-16.29–19.00, E-8.35–11.00; *P. auritus* (Lesson, 1831) C-22.31, C1-11.03, E-7.25; *M. pygmaeus* (Pallas, 1773) C-16.20–19.00, C1-9.4–10.02, E-6.10–7.00.

Name etymology: *Phalacrocorax* = genus name; *bakonyiensis* = from the Bakony Mountain.

Diagnosis: a species of cormorant smaller than the extant large cormorant, of intermediate size between the extant *Phalacrocorax auritus* and *M. pygmaeus*:

– *caput humeri* (a) is prominent, separated at ventral end by *incisura capitis* (b) from prominent middle part, unlike extant species;
– *tuberculum dorsale* (c) is rounded, damaged;
– *sulcus lig. transversus* (d) is deep, long and curved;
– *impressio coracobrachialis* (e) is deep, long and wide;
– *intumescentia humeri* (f) is broad, distally narrowing ovate, slightly convex;
– *crista delto pectoralis* (g) is damaged;
– *incisura capitis* (h) is wide and deep;
– *tuberculum ventrale* (i) is well developed, prominent;
– *fossa pneumotricipitalis* (j) is wide, deep, elongated and undivided (no *crus fossae*);
– *crista bicipitalis* (k) is less prominent;

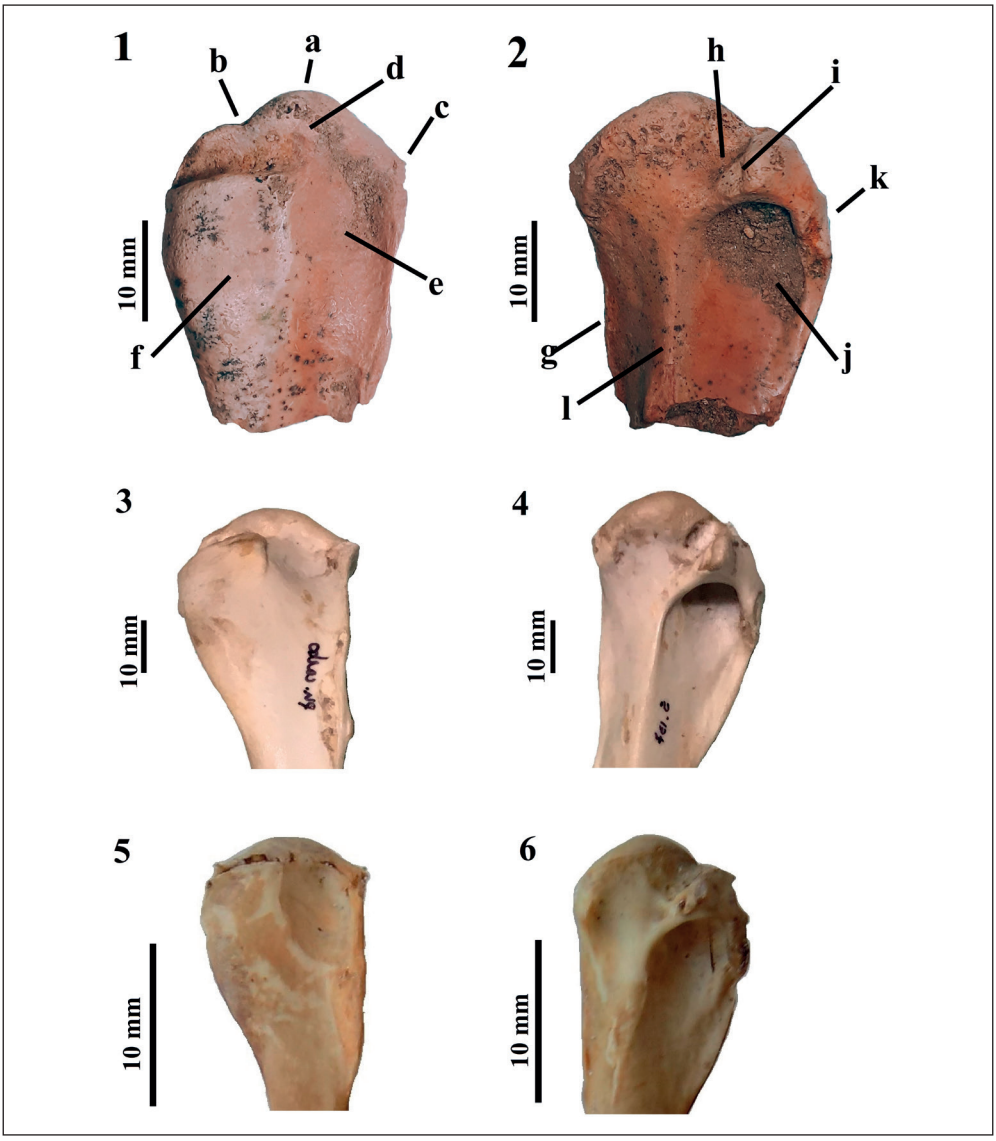

Figure 1. 1. *Phalacrocorax bakonyiensis* n. sp., left *humerus*, proximal epiphysis, lateral view: a. *caput humeri;* b. *incisura capiti;* c. *tuberculum dorsale;* d. *sulcus lig. transversus;* e. *impressio coracobrachialis;* f. *intumescentia humeri*; 2. *Phalacrocorax bakonyiensis* n. sp. left *humerus*, proximal epiphysis, medial view: g. *crista delto pectoralis;* h. *incisura capiti;* i. *tuberculum ventrale;* j. *fossa pneumotriccipitalis;* k. *crista biccipitalis;* l. *margo caudalis*; 3. *Phalacrocorax carbo* extant, left *humerus*, proximal epiphysis, lateral view; 4. *Phalacrocoax carbo* extant, left *humerus*, proximal epiphysis, medial view; 5. *Phalacrocorax pygmaeus* extant, left *humerus*, proximal epiphysis, lateral view; 6. *Phalacrocorax pygmaeus* extant, left *humerus*, proximal epiphysis, medial view. Scale mark: 10 mm

1. ábra 1. *Phalacrocorax bakonyiensis* sp. n. baloldali felkarcsont, proximális epifizis, laterális nézet: a. *caput humeri;* b. *incisura capiti;* c. *tuberculum dorsale;* d. *sulcus lig. transversus;* e. *impressio coracobrachialis;* f. *intumescentia humeri*. 2. *Phalacrocorax bakonyiensis* sp.n. baloldali felkarcsont, proximális epifizis, mediális nézet: g. *crista delto pectoralis;* h. *incisura capiti;* i. *tuberculum ventrale;* j. *fossa pneumotriccipitalis;* k. *crista biccipitalis;* l. *margo caudalis*. 3. *Phalacrocorax carbo* recens, baloldali felkarcsont, proximális epifizis, laterális nézet; 4. *Phalacrocorax carbo* recens, baloldali felkarcsont, proximális epifizis, mediális nézet; 5. *Phalacrocorax pygmaeus* recens, baloldali felkarcsont, proximális epifizis, laterális nézet; 6. *Phalacrocorax pygmaeus* recens, baloldali felkarcsont, proximális epifizis, mediális nézet. Méretarány: 10 mm

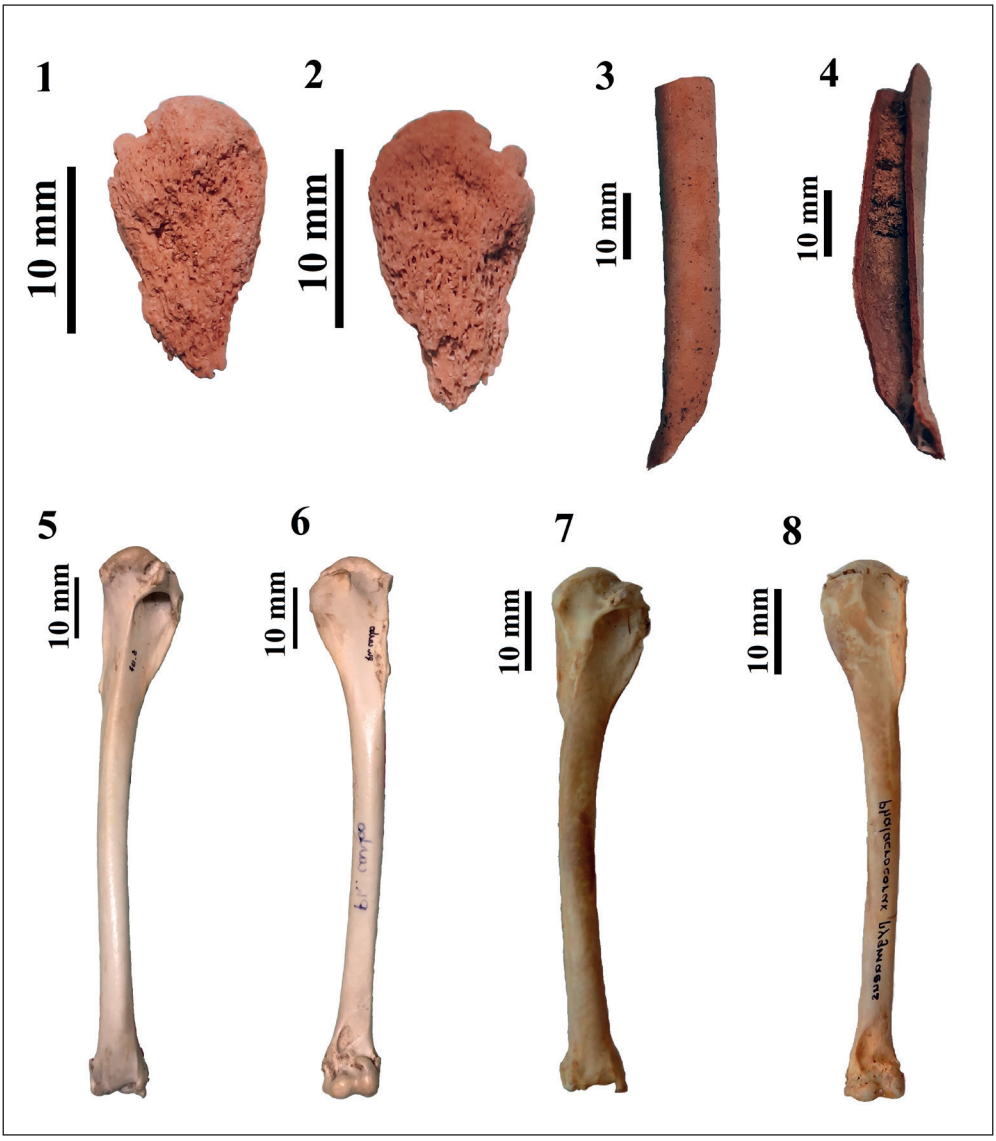

Figure 2. 1. juvenile *Phalacrocorax cf. bakonyiensis* left *humerus*, proximal epiphysis fragment, lateral view; 2. juvenile *Phalacrocorax cf. bakonyiensis* left *humerus*, proximal epiphysis fragment, medial view; 3. *Phalacrocorax cf. bakonyiensis* left *humerus* diaphisis fragment, lateral view; 4. *Phalacrocorax cf. bakonyiensis* left *humerus* diaphisis fragment, medial view; 5. *Phalacrocoax carbo* extant, left *humerus*, diaphisis fragment, medial view; 6. *Phalacrocorax carbo* extant, left *humerus*, lateral view; 7. *Phalacrocorax pygmaeus* extant, left *humerus*, medial view; 8. *Phalacrocorax pygmaeus* extant, left *humerus*, lateral view. Size mark: 10 mm.

2. ábra 1. Fiatal *Phalacrocorax cf. bakonyiensis* bal felkarcsont, proximális epifízis töredék, oldalnézet; 2. Fiatal *Phalacrocorax cf. bakonyiensis* bal felkarcsont, proximális epifízis töredék, mediális nézet; 3. *Phalacrocorax cf. bakonyiensis* bal felkarcsont diafízis töredék, oldalnézet; 4. *Phalacrocorax cf. bakonyiensis* bal felkarcsont diafízis töredéke, mediális nézet; 5. *Phalacrocoax carbo* bal felkarcsont, diafízis töredéke, mediális nézet; 6. *Phalacrocorax carbo* extant, bal felkarcsont, laterális nézet; 7. *Phalacrocorax pygmaeus* bal felkarcsont, mediális nézet; 8. *Phalacrocorax pygmaeus* bal felkarcsont, laterális nézet. Méretarány: 10 mm

– *margo caudalis* (l) is curved, well developed, sharp;
– the shape of the diaphysis fragment corresponds to that of the genus.

The proximal epiphysis of the *humerus* is preserved to the distal end of the *crista delto pectoralis*. The marks indicated in the diagnosis of the species in the two extant species (*Phalacrocorax carbo* and *M. pygmaeus*) are as follows:

In *Phalacrocorax carbo* extant:
– *caput humeri* is flat, ventral end not separated by a small strap on the lateral side;
– *tuberculum dorsale* is prominent;
– *sulcus lig. transversus* is deep, short, broad;
– *impressio coracobrachialis* is less deep, long and wide;
– *intumescentia humeri* is broad, distally narrowing ovate, flat;
– *crista biccipitalis* is bulging;
– *incisura capiti* is ovate;
– *tuberculum ventrale* is well developed, prominent;
– *fossa pneumotricipitalis* is narrow, deep, elongated and slightly divided with *crus fossae*;
– *crista delto pectoralis* is slightly concave straight;
– *margo caudalis* is straight, well developed, sharp.

In *Microcarbo pygmaeus* extant:
– *caput humeri* is flat, ventral end on lateral side not separated by a small ligament from the apical part;
– *tuberculum dorsale* is prominent;
– *sulcus lig. transversus* is long, straight;
– *impressio coracobrachialis* is deep, short, ovate;
– *intumescentia humeri* is proportionally narrow, elongated, flat;
– *crista bicipitalis* is slightly curved;
– *incisura capitis* is wide and deep;
– *tuberculum ventrale* is well developed, prominent;
– *fossa pneumotricipitalis* is narrow, deep, elongated and slightly divided with *crus fossae*;
– *crista deltopectoralis* is forms a straight edge;
– *margo caudalis straight* is well developed, blunt.

Compared with known fossil cormorant species, it has the following morphological characteristics, but differs slightly from the extant species. The known European species of the Late Miocene do not have a *humerus*, and we were unable to compare the Bulgarian *P. serdicensis*, but the dimensions of the Sümeg find suggest that it is smaller than this species.

Conclusions

The new fossil species indicates a small-sized cormorant with the characters of the genus, with the differences listed in the diagnosis compared to the extant large and small cormorants. Its presence at the cave site indicates a former wetland habitat and the remains are part of

the prey of a larger owl. The fact that both adults and juveniles are present in the much richer specimen collected earlier suggests the former existence of a larger population in the vicinity of the site. The presence of a juvenile specimen was based on the fact that a single species was recovered from the cave sediments and that there were juveniles among the lost bones, and that the characteristics of the bone fragment, despite its juvenile state, were consistent with the *humerus* of a cormorant. Considering that cave bird fossils can only be dried from owl droppings, this is supported by the discovery of bird bones of different ages.

The stronger indentation of the *incisura capiti* on the lateral side (b) compared to the extant species may suggest a better flight ability, as the tendon of the *m. coracobrachialis* enters the *impressio coracobrachialis* on the medial side through this, where it attaches and moves the *humerus* forward *(anteflexion)*.

Phalacrocorax carbo, *Microcarbo pygmaeus* and *P. bakonyiensis* were used to indicate differences, but we do not have enough fossil and recens material for deeper conclusions. As regards the size, we would like to stress once again that we have not found any data in the literature that would allow us to make a comparison with small cormorant *humerus*.

Acknowledgements

The authors wishes to express their deep gratitude to Mihály Gasparik for access in recent bird bone collection in the Natural History Museum of Hungary and to Prof. Dr. Sándor Faragó for making the research work possible.

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