

**A new species of *Varanus* (Anguimorpha, Varanidae) from the early Miocene of Czech Republic and its relationships and palaeoecology**

MARTIN IVANOV<sup>1\*</sup>, MARCELLO RUTA<sup>2</sup>, JOZEF KLEMBARA<sup>3</sup> and  
MADELAINÉ BÖHME<sup>4</sup>

<sup>1</sup>*Department of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*

<sup>2</sup>*School of Life Sciences, Joseph Banks Laboratories, University of Lincoln, Lincoln LN6 7DL, UK*

<sup>3</sup>*Department of Ecology, Faculty of Natural Sciences, Comenius University in Bratislava, Mlynská dolina, Ilkovičova 6, 842 15 Bratislava, Slovakia*

<sup>4</sup>*Senckenberg Center for Human Evolution and Palaeoecology (HEP), University of Tübingen, Institute for Geoscience Paleontological Collection and Museum, Sigwartstrasse 10, D-72076 Tübingen, Germany*

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\* E-mail: [mivanov@sci.muni.cz](mailto:mivanov@sci.muni.cz); phone: +420-549 49 4600

## Abstract

Skeletal remains of a new early Miocene (Ottangian, MN 4 mammal zone) monitor lizard, *Varanus mokrensis* sp. nov., are described from two karst fissures in the Mokrá-Western Quarry (1/2001 Turtle Joint; 2/2003 Reptile Joint), Czech Republic, providing the first documented example of a European varanid for which osteological data permit a well-supported assignment to the genus *Varanus*. ~~The new specimen-species is~~ morphologically similar to the Recent Indo-Asiatic varanids of the *Varanus bengalensis* group. It differs from all other *Varanus* species on the basis of a single autapomorphy and ~~the a~~ combination of 11 characters. As a distinguishing feature of *V. mokrensis* sp. nov., the parietal and squamosal processes of the postorbitofrontal form a narrowly acute angle. The teeth show ~~a~~ distinct, smooth cutting edges along the mesial and distal margins of the apical portion of their crowns. This feature is not observed in most extant Asiatic *Varanus* species and may represent a plesiomorphic condition.

The results of parsimony phylogenetic analyses, with and without character reweighting, reveal poor resolution within *Varanus*. A Bayesian analysis shows *V. mokrensis* to be closely related to extant representatives of the Indo-Asiatic *Varanus* clade, with close affinities to the *V. bengalensis* species group. The topology of the Bayesian tree supports the hypothesis that Miocene monitors from Mokrá are representatives of a lineage that is ancestral to the well defined clade of extant African varanids, including the early Miocene *V. rusingensis*. In addition, our results support a Eurasian origin for the varanid clade. ~~Extant-The extant~~ African *Varanus* species probably originated in the late Oligocene. The radiation of African varanids probably occurred during the late Oligocene to early Miocene time interval.

The occurrence of *Varanus* in the early Miocene of Mokrá-Western Quarry corresponds to the warm phase of the Miocene Climatic Optimum. Remains of a diverse aquatic and heliophobe amphibian fauna at the 2/2003 Reptile Joint site indicate more humid conditions than those at the 1/2001 Turtle Joint site.

ADDITIONAL KEY WORDS: morphology – palaeoecology – phylogeny – skull – *Varanus*.

## Introduction

The anguimorph genus *Varanus* includes today's monitor lizards (Varanidae Hardwicke & Gray, 1827), a clade of mid-sized to large, mostly carnivorous (some frugivorous) squamates widely distributed in tropical and subtropical regions, and with a fossil record dating back to the Late Cretaceous. Altogether, 79 valid species are currently assigned to *Varanus* (Böhme W. 2003; Koch *et al.* 2010; Uetz *et al.* 2017). Most published checklists recognise three major species groups formally supported by mtDNA analyses (e.g. Ast 2001), namely an African group, an Indo-Asiatic group (divided into two distinct clades), and an Indo-Australian group. Unlike mtDNA analyses, all morphological studies place the family Varanidae Hardwicke & Gray, 1827 (e.g. McDowell & Bogert 1954; Estes 1983; Carroll 1993) in a clade Varanoidea Munster, 1834 (= Platynota Baur, 1890 *sensu* Estes 1983; Carroll 1993) together with two other extant families, the ~~(~~Helodermatidae Gray, 1837 and the Lanthanotidae Steindachner, 1877~~)~~. However, several studies have recognised only two extant family-rank clades within Varanoidea, namely Helodermatidae and Varanidae. The close relationship between *Varanus* and *Lanthanotus* has long been supported by

morphological studies of extant taxa (Rieppel 1980a, 1980b), and further corroborated by mtDNA analyses (Fuller *et al.* 1998; Ast 2001).

This paper has three aims: 1) we provide a detailed description of the cranial and postcranial material of a new species of *Varanus* from the early Miocene deposits of the Mokrá-Western Quarry locality in the Czech Republic; 2) we analyse the interrelationships of *Varanus*; and 3) we investigate the palaeoecology of the Mokrá-Western Quarry. The anatomical terminology is based on Fejérváry-Lángh (1923), Fejérváry (1935), Bahl (1937), Säve-Söderbergh (1946, 1947), Bellairs (1949), Oelrich (1956), Romer (1956), Shrivatsava (1963, 1964a, 1964b), Hoffstetter & Gasc (1969), Bellairs & Kamal (1981) and Conrad (2004, 2006).

#### **Brief review of the fossil record of varanoids and *Varanus***

The interrelationships of varanoids remain in a state of flux. Several key fossil taxa, including *Saniwa* Leidy, 1970, *Saniwides* Borsuk-Białynicka, 1984, and *Cherminotus* Borsuk-Białynicka, 1984 (Gilmore 1922, 1928; Borsuk-Białynicka 1984), have been largely neglected in phylogenetic analyses, including many of the earliest large-scale studies of squamate relationships (Pregill *et al.* 1986; Estes *et al.* 1988). Other extinct varanoid generas described in the last few decades, including *Estesia*, *Aiolosaurus*, and *Ovoo* (Norell *et al.* 1992; Norell *et al.* 2007; Norell & Gao 1997; Gao & Norell 2000), require proper phylogenetic placement. Based on comparative osteological observations, Lee (1997) regarded the Late Cretaceous *Saniwides* from Mongolia (Borsuk-Białynicka 1984; Pregill *et al.* 1986; Estes *et al.* 1988) as the sister taxon to *Varanus* Merrem, 1820. However, *Saniwa* and *Cherminotus*, both assigned to Varanidae together with the Late Cretaceous *Telmasaurus* and extant *Varanus* (Gao & Norell 1998), are probably more closely related to *Varanus* than *Saniwides* is (Norell &

Gao 1997; Gao & Norell 1998; Norell *et al.* 2007; Rieppel & Grande 2007). The Late Cretaceous (Campanian) *Ovoogurvel* from Mongolia has been described as a stem-*Varanus* (Norell *et al.* 2007). Aside from its possible impact on the interrelationships of varanoids as a whole interrelationships, our knowledge of Late Cretaceous varanoids has interesting palaeobiogeographical implications. ~~Specifically, thus,~~ data from these taxa may support an Asiatic rather than an African origin for the radiation of European radiation of *Varanus* species.

The oldest fossils attributed to *Varanus* consist of vertebrae from the late Eocene of the Birket Qarun Formation in Egypt (Holmes *et al.* 2010). The earliest recorded European species in this genus, commonly referred to as *Iberoveranus catalaunicus* (Hoffstetter, 1969), comes from the MN 3/MN 4 mammal zone transition of Spain (type material from Can Mas, El Papiol, Barcelona), France, and Germany (Böhme 2001). However, *Iberoveranus* has been recently synonymized with *Varanus* and the species *V. catalaunicus* is now regarded as a *nomen dubium* (Delfino *et al.* 2013a). Other more or less contemporary localities have yielded *Varanus* or *Varanus*-like remains, including Spain (*Varanus* sp. from San Roque 4A; aff. *Iberoveranus* sp. and *Iberoveranus* cf. *I. catalaunicus* from Agramon and Ateca 1; Böhme & Ilg 2003), France (*Varanus* sp. from Artenay and Béon 1; Rage & Bailon 2005), Germany (*Iberoveranus* and *Varanus* from Petersbuch 2 and 28; Böhme 2002; Böhme & Ilg 2003), and Czech Republic (Mokrá-Western Quarry site; Ivanov *et al.* 2006).

Four valid extinct species of *Varanus* are reported from Europe and Africa. The first species is *V. rusingensis* Clos, 1995 from the early Miocene of Kenya, Rusinga Island, Kiakanga Hill. ~~The oldest known representatives of this species which~~ are known from the Songhor site (~20 Ma; Clos 1995; Rage & Bailon 2005). The second species is *V. hofmanni* Roger, 1898 from the middle Miocene (MN 6 mammal zone) of

Stätzing, Germany (Roger 1898, 1900; Fejérváry 1918; Hoffstetter 1969), also known from the early to late Miocene of France, Spain, Austria, and Hungary (Hoffstetter 1969; Alférez Delgado & Brea López 1981; Tempfer 2005; Venczel 2006; Ivanov 2009). However, the type material of *V. hofmanni* is represented by one cervical [vertebra](#), three trunk [vertebrae](#), and one caudal vertebra, ~~and~~ [This taxon](#) is regarded by some authors as [a nomen dubium](#) (Böhme 2002; Delfino *et al.* 2011). The third species is *V. (Varaneades) amnhophilis* Conrad, Balcarcel & Mehling, 2012 from the late Miocene (Turolian) of Samos (Greece) (Conrad *et al.* 2012). The fourth species is *V. marathonensis* Weithofer, 1888 from the late Miocene and early Pliocene of Spain, Greece, Hungary, and Turkey (Weithofer 1888; Bolkay 1913; Fejérváry 1918; Rage & Sen 1976; Sen & Rage 1979; Estes 1983; Delfino *et al.* 2013b; Pérez-Ramos *et al.* 2016). *Varanus* sp. from the middle Miocene of Gratkorn (Austria) is based on a well-preserved dentary, [a](#) fragmentary maxilla, and several vertebrae and ribs (Böhme & Vasilyan 2014).

Middle and late Miocene varanids from Kazakhstan (*V. pronini* Zerova & Chkhikvadze, 1986), Ukraine (*V. semjonovi* Zerova, 1986), and Moldova (*V. tyrsiensis* Zerova & Chkhikvadze, 1983; *V. lungui* Zerova & Chkhikvadze, 1986) are known exclusively from several isolated vertebrae (Lungu *et al.* 1983; Levshakova 1986; Zerova & Chkhikvadze 1984, 1986). Presumed autapomorphies of these species may in fact be attributed to incomplete preservation and/or intraspecific variation. Therefore, the status of these four taxa must await a thorough revision of available material.

An additional species, *V. darevskii* Levshakova, 1986, known from incompletely preserved skull material from the early Pliocene of Tadjikistan, has been attributed to the subgenus *Psammosaurus* Fitzinger, 1826 and [is](#) hypothesized to be closely related to

the extant *V. (Psammosaurus) griseus* (Daudin, 1803). However, Levshakova's (1986) assignment was questioned by Molnar (2004).

The large *V. sivalensis* Falconer, 1868 from the Pliocene – early Pleistocene of Siwalik Hills, India (Falconer 1868), was described on the basis of a fragmentary humerus and two trunk vertebrae. Although its humerus is distinct from that of the very similar extant *V. komodoensis* Ouwens, 1912, its trunk vertebrae fall within the range of morphological variation documented in Recent *V. salvator* (Laurenti, 1768), thus casting doubt on its affinities to *V. komodoensis* (Hocknull *et al.* 2009).

To sum up, many nominal fossil varanid species are based on insufficient material (mostly isolated vertebrae). The European *V. catalaunicus* is a *nomen dubium*, and *V. pronini*, *V. semjonovi*, *V. tyrsiensis*, and *V. lungui* are also regarded by some authors as *nomina dubia* (Delfino *et al.* 2011), and need revision (Rage & Bailon 2005).

## Material and methods

Abundant early Miocene (MN 4) vertebrate material, including varanids, has been reported from two karst fissures in Moravia (Czech Republic): 1/2001 Turtle Joint and 2/2003 Reptile Joint (Fig. 1). The new early Miocene *Varanus* species from Mokrá-Western Quarry described here represents one of the oldest known and most complete European records of this genus. Its discovery is particularly important in light of its cranial anatomical features, which are unique among [early Miocene](#) European [early Miocene](#) varanids.

Four fossiliferous karst fissures were discovered in the course of fieldwork undertaken in the years 2002–2005 on karst floors at 410 m above sea level (a.s.l.), 395 m a.s.l., and 380 m a.s.l. ~~All material from T~~ the two most fossiliferous fissures

(altogether 7.5 m<sup>3</sup>, about 13 tons) ~~are~~, both from the floor at 380 m a.s.l., and ~~are~~ labelled as 1/2001 (from Turtle Joint) and 2/2003 (from Reptile Joint) ~~hereafter~~. All material from these two fissures was washed in sieves of 2 mm, 1 mm, and 0.5 mm mesh size. In order to separate ~~the osteological material~~ fossil specimens from the non-calcareous sand-clayey sediments, we used H<sub>2</sub>O<sub>2</sub> in aqueous solution with optimum concentration corresponding approximately to a 1 (H<sub>2</sub>O<sub>2</sub> 30 %) : 100 (H<sub>2</sub>O) ratio. After dissolving the clayey component, we used a regulated stream of running water for final washing. An electron environmental microscope LEO 1540 VP and Leica MZ 16 microscopic system equipped with a Leica DFC 480 digital camera (5 mpx) were used for examination and photographs of the ~~isolated~~ fossil material.

The following osteological specimens were used for comparative studies (see below for a list of institutional abbreviations): *V. niloticus* (UF 56876, female, Togo; MNHN 1964-50; MNHN 1968-152; MNHN 1921-260; NMP6V 25930; NMP6V 25931; BMNH 97.5.3,1.2,1; BMNH I; BMNH 1935.8.3.1; BMNH II; BMHN 1900.9.22.9; BMNH 1970-1983; SMF 83055; SMF 33252; SMF 33253; SMF 11618), *V. n. niloticus* (SMF 47171; SMF 53197; SMF 32909), *V. n. ornatus* (SMF 54117; juv., SMF 34427; juv., SMF 34426), *V. albigularis* (BMNH 1908.4.27.35), *V. prasinus* (UF 56077, male, length 775 mm; UF 56949; BMNH 78.10.16.38), *V. p. prasinus* (SMF 69454; SMF 11626), *Varanus prasinus beccarii* (SMF 11636), *V. olivaceus* (UF 53917, female, Philippines, Luzon; UF 57536, male, Philippines, Luzon; SMF 72156), *V. salvadorii* (SMF 58064; SMF 67670), *V. flavescens* (ZZSiD 456; UF 64743, male, ZOO Miami; SMF 54157; SMF 11546), *V. salvator* (MNHN 1886-284; MNHN 1912-423; ZZSiD 256; BMNH 1972-2161; BMNH 1972-2160; BMNH 64.9.2.77; BMNH R.R.1961.-1761; SMF 81057; SMF 33130; SMF 33128; SMF 40178; SMF 40176; SMF 40177; SMF 11563), *V. salvator salvator* (SMF 33133; SMF 72158; SMF 33127; SMF

33148; SMF 32807; SMF 33126; SMF 40175; SMF 66647; SMF 33132), *V. salvator cumingi* (SMF 11577), *V. salvator marmoratus* (SMF 11571), *V. exanthematicus* (MNHN 1910-7; BMNH 1974.2480; disartic. BMNH 1920.1.20.3660; BMNH 1920.1.20.3755), *V. exanthematicus exanthematicus* (SMF 33258), *V. exanthematicus microstictus* (BMNH 1964-744; SMF 40161; SMF 11545), *V. exanthematicus angolensis* (SMF 21573), *V. exanthematicus albigularis* (SMF 11543), *V. indicus* (male, BMNH 1932.7.19.2; SMF 33290; SMF 79184; SMF 11635; SMF 72521; SMF 32808; SMF 11580), *V. rudicollis* (SMF 59239; SMF 40207; male, SMF 59216; SMF 59242), *V. bengalensis* (MNHN 1886-649; MNHN 1884-4; BMNH 1974.2479), *V. bengalensis bengalensis* (SMF 60428; SMF 63456), *V. bengalensis nebulosus* (SMF 11554), *V. griseus* (MNHN 1895-366; MNHN 1909-401; MNHN 1909-402; NMP6V 22948; NMP6V 22180; NMP6V 22181; BMNH 71.6.6.2; SMF 71569), *V. nebulosus* (BMNH 1931.1.12.1), *V. dumerilii* (SMF 11557), *V. dumerilii dumerilii* (SMF 11556), *V. timorensis* (BMNH 90.1.14.12), *V. gouldii* (BMNH 1983-1132; SMF 53276; SMF 11620), *V. gouldii gouldii* (SMF 59018), *V. gilleni* (BMNH 1910.5.28.13; SMF 11627), *V. giganteus* (SMF 53263), *V. acanthurus brachyurus* (SMF 11639; SMF 11642), *V. spenceri* (SMF 53277), *V. tristis tristis* (SMF 11630), *V. jobiensis* (SMF 75817), *V. eremius* (SMF 11648), *V. caudolineatus* (SMF 40086), *V. mertensi* (SMF 53275), *V. varius* (MNHN 1891-853; MNHN 1895-390), *V. komodoensis* (BMNH 1934.9.2.1).

### Body size estimation

We follow Conrad *et al.* (2012: table 1) in using snout-vent length (SVL) as a proxy for body size (tail length is variable even within individual species). The length of the posteriormost presacral vertebra (DVL) of fossil *Varanus* from Mokrá-Western Quarry was compared to ~~vertebral-vertebrae measurements~~ of *Varanus* ~~species inef~~ the ‘Indo-

Asiatic A' clade (*sensu* Ast 2001), based on the assumption that the new taxon scaled similarly to members of that clade. ~~In particular, the vertebra in question, and resembles~~ closely ~~taxa those of taxa of in~~ the *V. bengalensis* group (Conrad *et al.* 2012). ~~The Body size estimations were based on a~~ regression analysis ~~was~~ performed in STATISTICA, version 10.

### Phylogenetic analysis - technical aspects

In order to assess the phylogenetic position of the new *Varanus* species, we assembled a data matrix of 449 osteological characters coded for 87 taxa. We included extant and extinct *Varanus* species, ~~and as well as a number of several~~ outgroup taxa selected according to the results of the most recent ~~topologies of~~ squamate phylogenies (Appendices I and II, online supplementary material; Conrad *et al.* 2012). We performed two ~~two~~-maximum parsimony analyses and ~~a two~~ Bayesian inference analyses. The two parsimony analyses, carried out in TNT v. 1.1 (Goloboff *et al.* 2008), differed in the use of equal vs. implied weighting of characters (Goloboff 1993). In both cases, a reduced version of the data matrix was used, after applying safe taxonomic reduction (Wilkinson 1995) in the Claddis package of R (Lloyd 2015). The parsimony settings were as follows: heuristic searches; 50000 random stepwise addition sequences; tree bisection-reconnection branch-swapping algorithm, keeping a single tree in memory at the end of each addition sequence; branch-swapping subsequently applied to all trees in memory, with the option of saving multiple trees (Quicke *et al.* 2001). The same settings were applied to the ~~reweighted-implied weighting~~ analysis, ~~for which we used implied weighting (Goloboff 1993)~~. This technique assigns an implied weight W to each character, measured as  $W = K/(K + \text{Max} - \text{Obs})$ , where Max and Obs are, respectively, the maximum possible ~~number of changes of a character~~ and the

observed number of changes ~~for a character, respectively~~.  $K$  is a constant of concavity, an integer that ultimately determines the most parsimonious tree as the tree which maximizes the  $W$  value across all characters. The Bayesian analysis (Appendices III and IV, [online supplementary material](#)) ~~was~~ was carried out in MRBAYES v. 3.0b4 (Huelsenbeck & Ronquist 2001) with the following default settings: equal prior probability of all tree topologies; unconstrained branch lengths; equal state frequencies. Briefly, Bayesian analysis establishes the posterior probability of a tree given a data matrix, a model for character evolution, and a prior model of character-state frequency (e.g., Pollitt *et al.* 2005). The posterior probability of a tree is proportional to its likelihood times the prior probability of that tree (i.e., the probability without reference to the original matrix). The tree landscape is explored using Markov Chain Monte Carlo (MCMC) algorithms to find trees that have maximal posterior probability. The distribution of the posterior probabilities is represented by a 50 percent majority-rule consensus in which the Bayesian support is given as a posterior probability on all internal branches. The support value on a branch is interpreted as the probability of retrieving the group subtended by that branch, given the data matrix, the model of character evolution, and the character-state frequency (e.g., Archibald *et al.* 2003). We carried out 1,000,000 MCMC iterations, sampling every 100th generation, and discarding the first 10000 trees following the recommended burn in. We considered all posterior probability values above 90 percent to be strong, those below 50 percent to be weak (e.g., Tsuji *et al.* 2010). In the Bayesian topologies, a value of 1 indicates the probability of the partition indicated by the relevant branch. For ease of figure presentation, we indicate only partitions with a value of 1; all the others have a value of 0.5. Using the Markov k (Mk) model for morphological data, we specified two types of rate distribution for character changes across the tree, namely equal and gamma,

permitting respectively equal probability of between-state changes and variable rates of change across characters (e.g. Tsuji *et al.* 2010; Wright & Hillis 2014). Stationarity was deemed to be satisfactory, with split frequencies values only slightly higher than 0.05.

**Institutional abbreviations.** MNHN, Muséum national d'Histoire naturelle, Paris; NHM (BMNH), Natural History Museum, London; NMP, National Museum, Prague; Pal., Department of Geological Sciences, Masaryk University, Brno; SMF, Senckenberg Museum, Frankfurt a. Mein; NMA, Naturmuseum Augsburg, Augsburg; UF, University of Florida, Gainesville; Pal., Collections of the Department of Geological Sciences, Masaryk University, Brno; ZZSiD, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków.

### Systematic palaeontology

Order **Squamata** Opperl, 1811

Superfamily **Varanoidea** Camp, 1923

Family **Varanidae** Hardwicke & Gray, 1827

Genus **Varanus** Merrem, 1820

† **Varanus mokrensis sp. nov.**

(Fig. 2–7)

**Diagnosis.** Mid-sized *Varanus* with estimated snout-vent length up to about 38 cm; differs from all other species in the genus on the basis of ~~one~~ a single autapomorphy - parietal and squamosal processes of postorbitofrontal forming a distinctly acute angle - and the following combination of features: 1) short septomaxilla with flat dorsal

surface; 2) frontal and anterolateral postorbital processes of postorbitofrontal forming obtuse angle; 3) posterior margin of nasal lobe of frontal situated in middle of dorsal width of rostral process; 4) posterior margin of anteroposteriorly elongated frontal relatively narrow; 5) parietal with wide subrectangular fronto-postfrontal processes, anteriorly arched fronto-parietal suture, and parietal foramen situated significantly posterior to anterior margin of bone (more than one-third of parietal plate length); 6) distance between medially converging parietal crests of parietal shortest in posterior one-fourth of parietal plate length; 7) otoccipital with very distinct occipital crest at base of paroccipital process; 8) pointed conical teeth with distally recurved apices and prominent smooth mesial and distal cutting edges; 9) trunk vertebrae with moderately developed depression between pars tectiformis and medial margin of prezygapophyses and with posterolaterally directed postzygapophyses forming a right angle; 10) praeacetabular process of ilium prominent and directed at right angle to pubic process; 11) bifurcated iliac crest prominent.

**Derivation of specific name.** The species name *mokrensis* refers to the Mokrá-Western Quarry locality.

**Holotype.** 2/2003 Reptile Joint: parietal (Pal. 1097, Fig. 3H, I).

**Paratypes.** 1/2001 Turtle Joint: left maxilla (Pal. 1023, Fig. 2A, B; Pal. 1024, Fig. 2C-E), left septomaxilla (Pal. 1020, Fig. 2I, J). 2/2003 Reptile Joint: left postorbitofrontal (Pal. 1117, Fig. 3A, B), left frontal (Pal. 1090, Fig. 3E, F), parietal (Pal. 1098, Fig. 3G), left palatine (Pal. 1134, Fig. 4A, B), right pterygoid (Pal. 1131, Fig. 4D, E), right quadrate (Pal. 1152, Fig. 4F), right prootic (Pal. 1104, Fig. 4G, H), left otoccipital (Pal.

1109, Fig. 4J-M), basioccipital (Pal. 1014, Fig. 4N), basisphenoid (Pal. 1114, Fig. 5A-C), right dentary (Pal. 1140, Fig. 5E-G), left supraangular (Pal. 1144, Fig. 5H, I), right articular (Pal. 1150, Fig. 5K, L), left ilium (Pal. 1154, Fig. 5M, N), cervical vertebra (Pal. 1159, Fig. 6C, D), middle trunk vertebra (Pal. 1183, Fig. 6I-M). 1/2001 Turtle Joint: sacral vertebra (Pal. 1066, Fig. 6Q).

**Referred material.** 1/2001 Turtle Joint: frontal (2 left + 3 right), Pal. 1000-1004; parietal, Pal. 1005-1007; left prootic, Pal. 1008; otoccipital (1 left + 3 right), Pal. 1009-1012; basisphenoid, Pal. 1013; basioccipital, Pal. 1014-1015; postorbitofrontal (2 left + 2 right), Pal. 1016-1019; septomaxilla (2 left + 1 right), Pal. 1020-1022; maxilla (3 left + 2 right), Pal. 1023-1027; fragmentary toothed bones, Pal. 1028-1032; left pterygoid, Pal. 1033; right palatine, Pal. 1034; left dentary, Pal. 1035-1036; left supraangular, Pal. 1037; left articular, Pal. 1038; right quadrate, Pal. 1039; cervical vertebrae, Pal. 1040-1043; trunk vertebrae, Pal. 1044-1065; sacral vertebrae, Pal. 1066-1068; caudal vertebrae, Pal. 1069-1087.

2/2003 Reptile Joint: frontal (5 left + 4 right), Pal. 1088-1096; parietal, Pal. 1097-1103, prootic (2 left + 3 right), Pal. 1104-1108; otoccipital (2 left + 3 right), Pal. 1109-1113; basisphenoid, Pal. 1114-1116; postorbitofrontal (3 left + 2 right), Pal. 1117-1121; septomaxilla (2 left + 1 right), Pal. 1122-1124; maxilla (2 left + 4 left or right), Pal. 1125-1130; pterygoid (2 left + 1 right), Pal. 1131-1133; palatine (2 left + 1 right), Pal. 1134-1136; dentary (3 left + 4 right), Pal. 1137-1143; supraangular (3 left + 2 right), Pal. 1144-1148; articular (left + right), Pal. 1149-1150; quadrate (2 left + 1 right), Pal. 1151-1153; ilium (3 left + 2 right), Pal. 1154-1158; cervical vertebrae, Pal. 1159-1171; trunk vertebrae, Pal. 1172-1206; sacral vertebrae, Pal. 1207-1210; caudal vertebrae, Pal. 1211-1238.

**Type locality and horizon.** Mokrá-Western Quarry, Czech Republic: 1/2001 Turtle Joint and 2/2003 Reptile Joint. Both joints date back to the early Miocene, Eggenburgian or Ottnangian, Orleanian, MN 4 (Ivanov *et al.* 2006; Sabol *et al.* 2007).

**Repository.** Collections of the Department of Geological Sciences, Masaryk University, Brno, registration number SMM/009-09-11/372009, Pal. 1000-1238.

### **Skull**

**Maxilla.** The subtriangular maxilla contacts the premaxilla anteriorly, the septomaxilla, vomer, and premaxilla medially, and the prefrontal, lacrimal, jugal, ectopterygoid, and maxillary process of the palatine posteriorly (Fig. 2A-F). Its anteromedial extension forms the ventral rim of the exonarial fenestra (*excavatio nasalis sensu* Mertens 1942). All preserved maxillae are fragmentary with broken anterior and posterior extremities.

The sharp supradental shelf is expanded medially in its anterior part where it meets the vomer forming the posterolateral emargination of the external vomeronasal pit. The orifice of the infraorbital canal (for the nervus alveolaris superior and maxillary artery; Bellairs 1949), situated immediately dorsal to the supradental shelf, is delimited anterodorsally by a short, distinct crest. Anteriorly, the supradental shelf continues medially into a distinct facet for the contact with the vomer, and also forms the posterior margin of the exonarial fossa. The most complete left maxilla shows six tooth positions. Seven labial foramina occur in the most completely preserved maxilla. Foramina are more closely spaced anteriorly at the level of the posterior termination of the exonarial

fenestra. A distinct depression on the dorsal surface of the anterior part of the maxillary fragments indicates that the excavatio nasalis was relatively short **anteroposteriorly**.

**Remarks.** The prefrontal process is not preserved, but the facial process was presumably very tall in lateral view, as suggested by the inclination of the narial margin, and **enlarged** posteriorly **enlarged** near the contact with the prefrontal and lacrimal. In its general shape (Fig. 2G, H), the maxilla resembles that of *V. bengalensis* (Daudin, 1802), although in adults of the latter species the laterally depressed maxillary teeth do not have distinctly broad basal portions (Mertens 1942, Tab. 25: Fig. 195 and 196) and their crowns may be rounded in lateral view (Mertens 1942, tab. 25: fig. 196).

**Septomaxilla.** The approximately trapezoidal, paired septomaxilla is situated between the nasal process of the premaxilla and **both the** maxillae. Laterally, it borders the flat anteromedial margin of the maxilla (Fig. 2I, J). Its anterior part forms a short, stout process.

A distinct, ventrally positioned septomaxillary fossa is present. In life, **thise fossa housed the** cartilaginous capsule of the Jacobson's organ **was situated within the fossa**. The anteromedial margin of the fossa is broken. A triangular process with a distally narrowing longitudinal groove projects posteriorly from the fossa. **Thise** process extended dorsally over the paraseptal cartilage (Bellairs 1949; Jollie 1960). The sharp posterolateral process of the septomaxilla formed the roof of the free posterior termination of the chondrocranial lamina transversalis anterior. In dorsal view, a distinct sulcus is visible along the medial margin of the septomaxilla (sulcus pro ramus frontalis ophthalmici nerve [V] *sensu* Bahl 1937). In life, this sulcus probably accommodated the narrowing medial branch of the ethmoidal nerve (Shrivatsava 1963; Va, nervus

ophthalmicus + nervus ethmoideus *sensu* Bellairs 1949) ~~together with~~ and the collateral ethmoidal artery. A short crest is visible anterolaterally proximal to the suture with the widened rostral portion of the maxilla. The crest originally bordered a distinct groove that presumably extended anteriorly almost to the level of the foramen septomaxillaris anterior (for its position in extant *V. bengalensis*, see Fig. 2G). The lacrimal duct (ld 2 - lower lacrimal duct *sensu* Shrivatsava 1963) was situated within the groove in life, and presumably ran ventrally and medially and opened below the Jacobson's organ (Bellairs 1949).

**Postorbitofrontal.** The paired postorbitofrontal is ~~posteriorly~~ enlarged posteriorly and forms two processes (Fig. 3A, B); situated along the medial and anterolateral margins of the bone. It articulates with the parietal and frontal medially and with the squamosal posteriorly.

In dorsal view, the postorbitofrontal contacts the posterolateral process of the frontal anteromedially via a long, robust, proximally wide frontal process (processus frontalis). The gracile distal termination of the process is not preserved, but it ~~was it~~ is assumed to have been very elongate, based on the strongly enlarged triangular facet for the postorbitofrontal attachment observed in the frontal bone. The postorbital and frontal processes are orientated slightly ventrally, and form an obtuse angle between them. The short posteromedially directed parietal process is attached to the anterolateral border of the parietal, ~~and; the process~~ forms a conspicuously acute angle with the posteriorly directed squamosal process (Fig. 3A – see arrow). The robust squamosal process was probably short and, together with the squamosum, participated in the formation of the anterior supratemporal arch.

**Remarks.** The angle between the frontal and parietal processes ~~can may~~ increase with age (Mertens 1942, tab. 23: 167; SMF 54157 – Fig. 3C), as documented for *Varanus flavescens* (ZZSiD 456) and *V. benagalensis* (BMNH 1974.2479 – Fig. 3D). ~~as~~ Such an increase a result of from the increasing anteroposterior width of the processus fronto-postorbitofrontalis of the parietal.

**Frontal.** The paired frontal forms most of the dorsal part of the orbital margin. The frontal cranial crests (cristae cranii *sensu* Oelrich 1956; ventro-lateral processes *sensu* Scanlon 2005) are the most prominent structures ~~of on~~ the ventral surface of the bone. They extend ventromedially and almost completely enclose the olfactory canal (Fig. 3E, F). The canal is subtriangular in cross-section.

In dorsal view, the medial and lateral margins of the frontal are parallel ~~to each other~~. The bone carries a short anteromedial process and a large posterolateral process. The bone is widest at the level of the parietal suture. Its medial margin is straight and smooth. Its posterolateral margin forms a strong process directed slightly posteriorly. This process would be wedged between the postorbitofrontal and the parietal in life. The triangular parietal tab is distinctly well developed. The posterior margin of the distinct lobus nasalis (margo nasalis posterior), where the frontal meets the posterolateral process of the nasal, is situated ~~in at the level of~~ the mid-width of the rostral process of the frontal. The medial descending process has a broad **base**. The lateral descending process is broken off close to its base. The flat dorsal surface of the frontal is smooth anterior to the orbital margin. The broad orbital portion of the bone shows traces of the dorsal sculpture in the form of polygonal fields separated by low weak ridges. In ventral view, the medioventrally directed ventrolateral process of the frontal cranial crest is distinctly developed. The frontoparietal suture is interdigitated. In

lateral view, the triangular depression for the articulation with the prefrontal is conspicuously developed, and its posterior margin reaches slightly posterior to the mid-length of the bone. The articular facet for the postorbitofrontal is indistinct. In medial view, the anterior portion of the dorsal margin of the frontal narrows, and the medial descending process of the bone is slightly inclined ventrally. In anterior view, the anterior margin of the crista cranii frontalis is directed distinctly ventrally, and its posterior margin is arched in a medial direction.

**Parietal.** The unpaired parietal covers dorsally the posterior portion of the braincase (Fig. 3G-I). It articulates with the frontal anteriorly and the parietal posteriorly. The frontoparietal suture is interdigitating. A flexible movable joint occurs between the parietal and the prootic.

In dorsal view, the flat parietal table is covered by a weakly developed ornamentation ~~formed consisting by of~~ irregular shallow grooves. The anterolateral processes are anteroposteriorly broadened and project slightly laterally. The distance between the medially converging parietal crests is ~~the~~ shortest at the level of the posterior one-fourth of the parietal table length. Further posteriorly, the parietal crest extends onto the dorsal surface of the incompletely preserved supratemporal processes. The basal portions of the posterolaterally diverging supratemporal processes form an almost right angle. The parietal crest contributes to the dorsal margin of a large and anteroposteriorly short supratemporal fossa, which extends from the postorbitofrontal articulation, through the parietal process, to the unpreserved posterior tip of the supratemporal process. The fossa is mediolaterally broadest immediately posterior to the level of the maximal constriction of the parietal crests. The anteromedial part of the

fossa is covered by the slightly extending parietal crest. The parietal foramen lies at level slightly anterior to the mid-length of the parietal table.

In ventral view, the facet for the articulation with the posterolateral process of the frontal is anterolaterally broad. The crista cranii parietalis is deepest halfway between the parietal foramen and the posterior border of the parietal table. Distinct marginal grooves are preserved on either side of the crista cranii in one specimen (Pal. 1097). The posterior section of the crista cranii is short and forms the anterolateral ~~restriction-constriction~~ of a deep depression visible at the base of the supratemporal process. The parietal fossa ~~is-forms~~ a wide and shallow depression ~~in-on~~ the posterior wall of the parietal table. In lateral view, the bases of the supratemporal processes are ~~flexed-orientated~~ ventrally. A ledge-like lateral margin of the parietal table covers the articulation of the parietal with the parietal process of the postorbitofrontal.

**Remarks.** The course of the parietal crests indicates a well-developed attachment for the musculus pseudotemporalis superficialis, ~~such as is found-~~ ~~In extant~~ durophagous ~~taxa-species of Varanus, e.g. extant-including~~ *V. niloticus*, *V. exanthematicus* ~~or and~~ *V. olivaceus* (Mertens 1942, tab. 23: fig. 166, 168). ~~In these species and~~ and ~~in the~~ extinct *V. rusingensis* from the early Miocene of Kenya (Clos 1995), the parietal crests approach one another closely in a posterior direction, ~~indicating a strongly developed musculus pseudotemporalis superficialis-~~ (Clos 1995). Such crests often occur in adult specimens and may form a distinct ~~crest-ridge~~ in the midline of the posterior margin of the bone (e.g. *V. olivaceus* - Mertens 1942, tab. 24: fig 172; SMF 72156). Specimens of *V. mokrensis* represent adults of average size (about 379.9 mm snout-vent length). ~~In this taxon, t~~The converging parietal crests ~~fail~~ing to come in contact with one another and the features of the dentition indicate that ~~the new taxon it~~ had a weaker

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pseudotemporalis superficialis muscle than the above mentioned species. We ~~deduce~~infer, therefore, that *V. mokrensis* was not a durophagous taxon.

**Palatine.** The irregularly shaped, toothless palatine bears three processes (Fig. 4A, B). The wide and posteriorly directed pterygoid process (broken off in all specimens) is connected to the pterygoid. The thin, anteromedially directed vomerine process connects to the vomer. The maxillary process is directed anteroposteriorly, but its anterior extremity is not preserved. The posterior end of this process contacts the jugal and ectopterygoid. The anterior border of the palatine forms the posterior margin of the internal nostril.

In anterior view, the infraorbital foramen (maxillo-palatine foramen *sensu* Mertens 1942 and Jollie 1960) forms the orifice of the superior alveolar canal running through the base of the maxillary process.

**Remarks.** The elliptical to almost circular infraorbital foramen of the palatine and the proximally slender processus vomerinus are also observed in extant *V. bengalensis* (MNHN 1884-4; MNHN 1886-649). The elongate maxillary process forms an obtuse angle with the vomerine process, and this ~~indicates~~suggests that the posterior nares were probably wide and short (as indicated also by the short septomaxilla) unlike in *V. bengalensis* (Fig. 4B, C – see arrows). The same development of posterior nares occurs in African monitors, which are considered to form the sister group to all other *Varanus* ~~taxa~~species.

**Pterygoid.** In ventral view, ~~t~~The triradiate pterygoid is slightly ~~medially flexed~~curved ~~medially in ventral view~~ and shows no trace of dentition (Fig. 4D, E). Its anterior

portion is flat, whereas its posterior portion forms a long and gracile quadrate process orientated posterolaterally. The anteromedial portion of the pterygoid projects into a flat and wide palatine process. The latter process articulates with the posterior border of the palatine. Anterolaterally, the pterygoid articulates with the ectopterygoid. The posterior terminations of all three processes are broken in all specimens.

In dorsal view, the crista columellaris anterior is wide and weakly developed. The crista columellaris posterior, forming the posteromedial border of the elongated fossa columellae, is sharp and decreases in height towards the posterior termination of the columellar fossa. The anterior margin of the columellar fossa reaches as far as the posterior termination of the markedly deep sulcus which widens and diminishes anteriorly. The basisphenoid process projects medially. The articulation surface for the basiptyergoid process of the basisphenoid is slightly rugose. In ventral view, the basal portion of the palatal process narrows posteriorly. The more ~~slender-gracile~~ ectopterygoid process is broken near its base. The low but distinct crista transversa dorsalis courses close to the lateral margin of the ectopterygoid process. The suborbital incisure is shallow and gradually merges into the wide base of the pterygoid process.

**Quadrate.** Only the trochlear part of the quadrate is present (Fig. 4F). It has a wide articular condyle for the junction with the articular. A small triangular facet for the articulation with the pterygoid is present at the medial border of the articular condyle. The tympanic fossa is deep and wide, and bears a wide outer ridge for the attachment of the dorsal and anterior borders of the tympanic membrane. The ~~lateromedially~~ wide and strongly developed posterior crest extends as far as the tympanic part of the articular condyle.

**Prootic.** The prootic forms the anterior and anteroventral portion of the auditory capsule (Fig. 4G, H). The prootic articulates with the supratemporal process of the parietal and the epipterygoid anterodorsally, the supraoccipital posterodorsally, the exoccipital posteriorly, the basioccipital posteroventrally and the basisphenoid anteroventrally. It is irregularly triaxial (Bellairs & Kamal 1981; Rieppel & Zaher 2000), and shows an alary process (processus prooticus anterioris superioris *sensu* Bellairs & Kamal 1981), an anterior inferior process (processus prooticus anterioris inferioris – *sensu in the sense of* Bellairs & Kamal 1981), and a posteriorly directed posterior process.

In lateral view, the anterior inferior process is dorsoventrally flattened. It is blunt and its anterior surface bears a shallow groove for the articulation with the alary process of the basisphenoid. A distinct rounded trigeminal notch occurs between the anterior inferior and the anterior superior processes. In ~~the extant~~ *specimens Varanus*, the ~~shallow~~ groove ~~participates in~~ ~~is adjacent to~~ the posterior ~~restriction~~ ~~narrower part of the~~ ~~a~~ membrane perforated by the ~~exit~~ orifice for ~~the exit~~ of the trigeminal nerve. The anterior superior process ~~is forms a~~ ~~movable~~ ~~articulation~~ ~~ed~~ with the ~~underside of the~~ lateral ~~internal~~ bevelled edge of the parietal and ~~with~~ the external dorsal ~~termination~~ ~~extremity~~ of the epipterygoid. The lateral crest (crista alaris prootici) is wide and blunt. The posterior process of the prootic ~~has a contact~~ ~~s with~~ the external surface of the paroccipital process of the otoccipital. The inferior process of the prootic ~~participates in~~ ~~a dorsal cover~~ ~~forms a crest~~ (crista prootica; crista otosphenoidea – *sensu in the sense of* Bahl 1937) ~~of~~ ~~situated dorsal to a~~ deep groove for the jugular vein (sulcus pro vena capitalis lateralis – *sensu in the sense of* Bellairs & Kamal 1981). A small foramen for the exit of the palatal branch of the facial nerve (VII. pal.) lies in the anterior section of the groove. Much larger foramen for the exit of the hyomandibular branch (VII. hm.) is situated just posterior to the former foramen. In medial view, the cavum vestibulare

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housing the membranous labyrinth (utricle + saccule) has a wide orifice. A somewhat smaller deep cochlear cavity, surrounded by strongly damaged cochlear ridge, occurs on its anteroventral portion.

~~There is a~~ large orifice for the vertically orientated anterior semicircular canal ~~is~~ situated at the anterior margin of the vestibular cavity. The orifice for the horizontal semicircular canal occurs inside the vestibular cavity ~~and~~ close to ~~its~~ ~~the~~ dorsal margin ~~of the latter~~, and ~~is situated~~ posteroventrally ~~from to~~ the orifice of ~~the~~ anterior semicircular canal. The horizontal semicircular canal passes along the external wall of the prootic and continues to the opisthotic portion of the otoccipital, close to the base of the inner margin of the processus prooticus posterioris. One to two minute foramina are situated at the base of the alary process, ~~just immediately~~ anteroventrally to the foramen for the anterior semicircular canal. A large foramen for the facial nerve (VII) is situated close to the base of the anterior inferior process.

**Remarks.** The posterior orifice for the Vidian canal of ~~the~~ basisphenoid is situated close to ~~the contact junction of this bone~~ with ~~the~~ prootic. ~~Such an orifice is~~ also documented ~~for in the~~ extinct *Varanus V. amnhophilis* and *Varanus V. priscus* (Owen, 1859) (Conrad *et al.* 2012: 5, fig. 2G, J; Head *et al.* 2009: 449). The prootic of *Varanus V. mokrensis* ~~closely generally~~ resembles that of *V. bengalensis* (MNHN 1886-649; MNHN 1884-4; SMF 63456), ~~but~~ ~~However, it~~ differs from ~~that the latter of extant V. bengalensis~~ (Fig. 4I – see arrow) ~~by in showing the a~~ more ~~massively built~~ ~~robust~~ lateral edge of the alary process (crista alaris prootici, Fig. 4G – see arrow).

**Otoccipital.** The otoccipital forms the posterolateral wall of the cerebral cavity and participates ~~at in~~ the formation of the posterior wall of the auditory capsule (Fig. 4J-M).

The substantial portion of the laterally projecting paroccipital process is formed by the opisthotic (Bellairs & Kamal 1981). The exoccipital portion articulates with the basioccipital ventrolaterally. The opisthoticum portion is situated almost at a right angle ~~to~~ with the exoccipital, and articulates with the prootic anteriorly and laterally, and with the posterior portion of the supraoccipital dorsally (Bahl 1937; Mertens 1942).

The opisthotic forms posterolaterally enlarged and ventrally directed process. The dorsally located rounded facet for the junction with the supratemporal occurs at the distal termination of the paroccipital process. The orifice of the horizontal semicircular canal is situated at the base of the paroccipital process. The inner exit of the semicircular canal is situated within the recessus utriculi, in the close vicinity-proximity to the medioventrally situated ampulla anterior, leading to the small orifice for the posterior semicircular canal. ~~A small~~ The orifice for the posterior semicircular canal is situated at the dorsal surface of the opisthotic portion. A depression situated at on the base of the paroccipital process marks the posterior boundary of the fenestra vestibuli. ~~A~~ There is a well preserved composite foramen for the exit of the cranial nerves X+XI, the entry of the occipital branch of the inner carotid artery, and the exit of the jugular vein, is well preserved. ~~A~~ The small foramen for the hypoglossal nerve (XII) is separated from the foramina for cranial nerves X+XI by a bony septum. Small foramina for the nerves XI (dorsally) and XII (ventrally) are situated close to the medial margin of the otoccipital. The ~~underneath~~ crista tuberalis is dorsally arched. The dorsal surface of the paroccipital process bears a deep and laterally enlarged depression posteriorly limited by the distinct lateral occipital crest. The slit-like jugular foramen for the common exit of the jugular vein and the cranial nerve X occurs at the posteroventral margin of the otoccipital.

**Basioccipital.** ~~Basioccipital~~ The basioccipital forms the floor of the posterior portion of the braincase (Fig. 4N). ~~Anteriorly, the basioccipital~~ It articulates with the basisphenoid anteriorly and laterally with the exoccipitals laterally.

In ventral view, the anteriorly widened margin of the basioccipital is either slightly convex ~~in its medial part~~ medially (Pal. 1014) or straight (Pal. 1015). The basipterygoid processes are situated laterally; their anterolateral margins protrude ventrally into the falciform speno-occipital tubercles ~~of the falciform shape~~ (Pal. 1014). The lateral margin of the ~~bone~~ basioccipital is slightly concave between the basipterygoid process and the strongly damaged occipitocondylar tubercle forming the medial portion of the occipital condyle. The ventral surface of the basioccipital is more or less flat. ~~The~~ Distinct depressions are present at the base of the basipterygoid processes of ~~the~~ larger specimens (Pal. 1014). The medial crest is indistinct (Pal. 1014). In dorsal view, ~~the~~ a shallow oval depression ~~is developed forming~~ marks the point where ventral delimitation of the medulla oblongata terminates.

**Remarks.** It is impossible to distinguish *Varanus* from Mokr-Western Quarry from extant representatives of *V. bengalensis* on the basis of preserved basioccipitals only. The basioccipital of *Varanus mokrensis* closely resembles that of *V. bengalensis* ~~by~~ in ~~the~~ the distinctly marked posteriorly ~~shifted~~ displacement of the basipterygoid processes ~~with and in the~~ more or less nearly straight ~~border~~ margin of the bone in plan view. Although Mertens (1942: 183) reported ~~a close~~ that similarity of the basioccipital morphology of *V. bengalensis* ~~with~~ is very similar to that of *V. salvator*, the ~~present comparative studies of~~ V. salvator shows ~~latter species exhibits~~ much more laterally enlarged depressions at the base of ~~the~~ its basipterygoid processes (MNHN 1886-284).

~~together with~~and the cranial ~~border margin~~ of the bone ~~that~~ is clearly convex (MNHN 1886-284; ZZSiD 256).

**Basisphenoid.** The basisphenoid forms the floor of the anterior braincase (Fig. 5A-C).

~~The~~Its straight posterior margin ~~of the basisphenoid~~ articulates with the basioccipital and, dorsally, with the prootic. The cultriform process (processus parasphenoideus) is not preserved.

In dorsal view, the posteriorly flexed anterior margin of the basicranial depression (crista sellaris; dorsum sellae – ~~sensu in the sense of~~Rieppel & Zaher 2000) covers the sella turcica. ~~A funnel-like hypophyseal fossa is present in~~ the central portion of ~~a~~the sella turcica, ~~a funnel-like hypophyseal fossa is present. The~~ ~~l~~ateral margins of the basicranial depression ~~are about of square shape and~~ protrude anterolaterally into the distinct wedge-like alary processes. ~~A posterior orifice~~ for the abducens nerve (VI) is situated in the anterolateral portion of the basicranial depression. ~~The~~Each basipterygoid process is directed anterolaterally. ~~The~~Its distal ~~termination extremity of the basipterygoid process is~~widens anteromedially and posterolaterally ~~widened~~. The anterior margin of the basicranial depression (crista sellaris) is ~~flexed orientated~~ ventrally and the anterior orifice for the abducens nerve (VI) is situated close to the dorsolateral margin of the sella turcica. The orifice is narrow or even slit-like. ~~The fossa~~ hypophyseos is divided by the distinct vertical retractor crest into two halves; the ~~foramina~~ for internal carotid artery ~~occur in both halves~~. The cranial branch of the internal carotid enters ~~these foramina, and passes~~ into the sella turcica. The anterior orifices of the Vidian canals for the transmission of the palatine branch of the internal carotid artery and the palatine branch of the facial nerve (vidian nerve – ~~sensu in the sense of~~Oelrich 1956) are situated within the slit-like depressions laterally bordered by

the short and sharp crests present at the base of the basiptyergoid processes. In lateral view, the basiptyergoid processes are anteroventrally directed and the posterior orifices of the Vidian canals (pVc – canalis Vidianus posterior) are situated ventral to the crista prootica, about ~~in the~~ half way between the base of the basiptyergoid process and the posterior border of the bone (Säve-Södenbergh 1947).

**Remarks.** The angle ~~between-formed by~~ the basiptyergoid processes of the basisphenoid is about 120° in ~~Varanus-V.~~ *V. mokrensis*, in contrast to about 90° in ~~the~~ extinct *V. darevskii* (Levshakova 1986: 103). The basiptyergoid processes of *V. mokrensis* are characterized by a narrow base and enlarged distal extremities, the latter being ~~d~~Distally narrower than those of extant African varanids – *V. niloticus* (Linnaeus, 1766), *V. exanthematicus* (Bosc, 1792), *V. albigularis* (Daudin, 1802), and *V. ornatus* Daudin, 1803 (see Mertens 1942; Ivanov - personal observation). The basisphenoid of *V. mokrensis* resembles most closely that of *V. bengalensis*; however, the posterior orifices of the Vidian canals are smaller in diameter and almost slit-like in ~~V. mokrensis~~ ~~the Miocene Varanus from Mokrá Western Quarry~~ and unlike the relatively large circular orifices observed in extant specimens of Bengal monitors (e.g. MNHN 1886-649). The anterior orifices of the Vidian canals are laterally bordered by distinct crests in *V. mokrensis*, whereas in *V. bengalensis* these crests are either absent or very slightly developed (Fig. 5C, D – see arrows). In cranial view, the ventral margins of the straight basiptyergoid processes form an obtuse-angled triangle in *V. mokrensis*, whereas *V. bengalensis* has relatively shorter basiptyergoid processes (Fig. 5C, D – see arrows).

#### Lower jaw

**Dentary.** Several highly fragmentary dentaries are preserved (Fig. 5E-G). Both the rostral and posterior portions of all fragments are broken. In medial view, the narrow sulcus Meckeli remains open throughout the entire length of the dentary. The best preserved fragment (Pal. 1140) possesses three tooth positions with two damaged teeth (Fig. 5E, F).

**Surangular.** One of several preserved surangulars is almost complete; only its posterior margin is missing (Fig. 5H-J). It is a massive and laterally compressed bone (Fig. 5H-K), anteriorly sutured to the dentary, dorsally to coronoid, ventrally and medially to splenial and articular, and ventrolaterally to angular.

In lateral view, a distinct orifice for the mandibular cutaneous nerve (posterior supra-angular foramen – ~~sensu in the sense of~~ Oelrich 1956), being a part of the mandibular division of cranial nerve V, is situated in close ~~vicinity-proximity~~ to the broken posterior tip of the bone. The canal passes through the posterior portion of the dentary, **which is triangular in cross-section**, and leads into the bone. Another foramen for re-entry of the dorsal branch of the mandibular nerve is situated close to the base of the coronoid process. The slit-like foramen which is visible from **anterolabial** view is surrounded by the bony tissue of surangular and situated in a shallow depression. In medial view, there is a distinct groove situated at the anterior termination of the fossa Meckeli. The groove was originally enclosed by **the** articular from both ventral and **medial** sides and also by the cuneate angular in its anterior portion. This wide mandibular canal, **which is circular in cross-section**, served for the entry of the inferior main branch of the mandibular nerve (nervus alveolaris inferior) and mandibular artery. At the same time, it served for the re-entry of the mandibular vein (Bahl 1937). The

deep groove situated at the anterodorsal portion of the surangular represents the re-entry of the canal for another branch of the mandibular nerve that passes through the entire length of the bone.

**Remarks.** The distinct foramen for re-entry of the dorsal branch of the mandibular nerve (Fig. 5J) is situated far from the anterior border of the bone. In African varanids, particularly in *V. niloticus* (e.g. MNHN 1964-50), this foramen is situated distinctly anteriorly. It is difficult to observe this foramen in numerous articulated specimens, e.g. *V. albigularis albigularis* (Daudin, 1802) (Mertens 1942, tab. 26: fig. 201) or *V. griseus* (e.g. MNHN 1895-366). The surangular of *V. mokrensis* closely resembles that of *V. salvator* (MNHN 1888-198) particularly by the length/height ratio and the convex body of the bone; the surangular of *V. bengalensis* (MNHN 1886-649) and *V. flavescens* (UF 64743) is relatively flat in contrast to that of *V. mokrensis*. However, the foramen for the re-entry of the dorsal branch of the mandibular nerve is situated even more posteriorly in *Varanus* from Mokrá-Western Quarry, approximately half way between the anterior border of the bone and the orifice of the distinct cutaneous nerve.

**Articular.** The articular is an elongated bone whose massive retroarticular process extends far behind the quadrate/articular joint (Fig. 5L, M). Only the posterior portion of the bone is preserved; it has a distinct transversely concave glenoid fossa. The retroarticular process is long and stout and its distal ~~termination-extremity is~~ somewhat widened posteriorly. A well-developed retroarticular fossa is situated posterior to the articular facet. An aperture for the entrance of the chorda tympani branch of cranial nerve VII occurs within the fossa.

**Dentition** (Fig. 2C-F, 5E-G). The teeth are conical and laterally flattened. They have mesiodistally broadened bases with distinctly developed longitudinal striations (as a result of furrowed plicidentine). The tooth bases of the fully developed teeth are either massive with small resorption pits or are formed by a system of laminae indicating an advanced stage of resorption preceding the tooth replacement (Rieppel 1978). Distinct and sharp cutting edges are present at the mesial and distal margins of the tooth crown; the surface of the cutting edge is smooth.

**Remarks.** The most immediately recognizable trait of the *Varanus mokrensis* dentition is the distinctly developed smooth cutting edge along the mesial and distal margins of the apical part of the tooth crown. Most of the extant Asiatic varanids have developed trenchant and posteriorly-directed teeth with indentated-serrated cutting edges. Varanids which have developed with a molariform dentition as a result of show adaptations on the durophagous mode of living durophagy (e.g. extant *V. niloticus*, *V. exanthematicus*, *V. olivaceus* and extinct *V. rusingensis*; Mertens 1942; Rieppel & Labhardt 1979; Clos 1995) may have developed a short cutting edge without indentation but this character was observed only in subadult specimens (Ivanov 2009). In members of the closest outgroup to *Varanus* (i.e., platynotan representatives of *Lanthanotus*, Helodermatidae, and Anguinae) the cutting edge is either absent or developed (but lacks indentation). Therefore, it is possible to presuppose that the presence of the smooth edge in adult specimens of *Varanus* represents plesiomorphic condition.

#### **Postcranial skeleton**

**Cervical vertebrae.** Most of the preserved cervical vertebrae are fragmentary, usually with broken neural spines and hypapophyses (Fig. 6A-D). The height of the neural spine depends on the position within the cervical region of the vertebral column. In lateral view, the posterior cervical vertebrae with distally broken neural spines were characterized by neural spines probably as long as high or somewhat lower in cranio-caudal direction. Anterior cervical vertebrae possess distinctly anteroposteriorly enlarged and conspicuously low neural spines. Anteriorly, the neural spine reaches the anterior margin of the neural arch. Posteriorly, the neural spine extends as far as the posterior termination of the neural arch. The bases of the transverse processes are directed laterally. The cranial margin of the hypapophysis extends as a low ridge as far as the vicinity of the cotylar rim. The hypapophysis distinctly rises ventrally at about centrum midlength. In dorsal view, the oval prezygapophyseal articular facets extend laterally to form the wide prezygapophyseal area. The interzygapophyseal constriction occurs about in the half of the vertebra length. In ventral view, the anterior margin of the vertebral centrum base is widened laterally and gradually passes into the transverse process. The posterior margin of the centrum is narrow anterior to the laterally wide condylar base. In anterior view, the neural arch is moderately vaulted. Its anterior margin is triangular to slightly round in cross-section and is situated between the markedly dorsally tilted prezygapophyses. The cotyle is prominently depressed dorsoventrally. The distal termination of the hypapophysis is pear-shaped and is distinctly developed particularly in the posterior cervical vertebrae.

**Remarks.** Fragmentary cervical vertebrae of *Varanus mokrensis* have developed hypapophyses with laterally widened distal terminations. This is typical for all representatives of the genus *Varanus*. Several fragmentary vertebrae from the cervical

region indicate that the neural spine of *Varanus mokrensis* was low and antero-posteriorly distinctly enlarged in contrast to all observed extant representatives of Indo-Asiatic group (Ast 2001). In this respect, cervical vertebrae of *V. mokrensis* resemble extant *V. griseus* recently inhabiting Africa and southwestern Asia.

**Trunk vertebrae.** Numerous well-preserved trunk vertebrae enable studies of the intracolumnar variability, particularly as regards the shape of the neural spine (Fig. 6E-M). In lateral view, the neural spine of the middle trunk vertebrae is about two to three times antero-posteriorly longer than tall. Its anterior margin is posterodorsally inclined; this inclination is more distinct in the posterior trunk vertebrae. Therefore, the distal termination of the neural spine is relatively short in the posterior trunk vertebrae. The synapophyses are massively built and markedly large in several vertebrae. The lateral foramina, which occur close behind the posterodorsal margin of synapophyses, are very small and indistinct. In dorsal view, the interzygapophyseal constriction occurs about at two thirds of the vertebra length close before the posterolaterally directed and laterally relatively narrow postzygapophyses (compared to prezygapophyses). The prezygapophyses are strongly laterally widened and the prezygapophyseal articular facets are of anterolaterally enlarged oval shape. The dorsal margin of the neural spine is posteriorly slightly laterally thickened. In ventral view, the vertebral centrum is elongated and wide anteriorly whereas the basal portion of the markedly laterally widened condyle is strongly constricted. Synapophyses are directed laterally. In cranial view, the prezygapophyses are conspicuously tilted dorsally, the synapophyses are short and directed laterally. The neural arch is moderately vaulted and its roof-like posterior margin rises dorsally to the base of the neural spine. The neural canal is irregularly circular to subtriangular in cross-section. The cotyle is depressed dorsoventrally. Small

paracotylar foramina are developed in depressions at both sides between the cotyle and upraising base of the prezygapophyses in many vertebrae. In some cases, the foramina are not paired and they are often **absent**.

**Sacral vertebrae.** All sacral vertebrae are fragmentary (Fig. 6N-Q). In ventral view, they differ from the vertebrae of the trunk region by the distinctly shorter centrum length/neural arch width ratio. The dorsoventrally depressed transverse processes are not distally narrowed. Typical is the presence of a groove at the posterior margin of the transverse processes. This groove is strongly widened **medially**. In posterior view, the condyle is distinctly **laterally** widened with a wide and shallow medial groove **extending dorsoventrally**.

**Caudal vertebrae.** Several preserved **caudal** vertebrae are fragmentary and with a broken neural spine (Fig. 6R, S). Rarely preserved isolated neural spines are posterodorsally strongly elongated. In dorsal view, the prezygapophyseal articular facets are oval and the dorsoventrally flattened transverse processes are directed laterally.

**Ilium.** One almost complete left ilium is characterised by the distinct bifurcated iliac crest situated dorsal to the acetabulum (Fig. 7A, B). In lateral view, the postacetabular process is massively built with a **dorsoventrally** wide base. The preacetabular process is prominent with a blunt termination; it is directed **at a right angle** to the pubic process of the ilium. The posterior margin of the ischial process is perpendicular to the direction of the **caudally projected** postacetabular process.

## **Comparisons and discussion**

Five extinct species of the genus *Varanus* - *V. hofmanni*, *V. amnhophilis*, *V. marathonensis*, *V. darevskii*, and *V. sivalensis* (East European taxa with poor description or illustration are excluded) are known from Eurasia, and two of those have been recorded from adjacent territories in eastern Europe and Asia: *Varanus darevskii* from Tadjikistan (Levshakova 1986) and *V. sivalensis* from India (Falconer 1868; Hocknull *et al.* 2009). Of those two species, only *Varanus darevskii* is known from cranial material (albeit incompletely preserved; Levshakova 1986). The two southeast European species *V. amnhophilis* and *V. marathonensis*, are generally acknowledged to represent valid species, the latter one, however, needs revision. The new species of *Varanus* from Mokrá-Western Quarry differs from all known extinct (including *V. darevskii*, *V. hofmanni*, *V. amnhophilis*, *V. marathonensis*, *V. sivalensis*, *V. hooijeri* (Indonesia; Brongersma 1958), *V. rusingensis* (Kenya) and *V. (= Megalania) priscus* (Australia; Owen 1859, 1880; Molnar 1990, 2004)) and extant species in one autapomorphic character which is the distinctly sharp angle between the parietal and squamosal processes of postorbitofrontal (Fig. 3A, D – see arrows). However, as regards extinct species of *Varanus*, the postorbitofrontal is preserved only in *V. darevskii*.

Furthermore, *Varanus mokrensis* differs from all known species of *Varanus* by the following combination of characters:

- 1) **The septomaxilla is** short with flat dorsal surface. *Remarks:* In *Varanus mokrensis*, the septomaxilla is shorter, anteroposteriorly enlarged and dorsal ridge is absent compared with that in *V. darevskii*; in all remaining seven extinct species, the septomaxilla is not preserved. If compared to extant species, the septomaxilla of *Varanus mokrensis* resembles only that in *V. bengalensis* by particularly posteriorly

enlarged medial process (Fig. 2G). The process is about twice as long as the lateral process. However, *V. mokrensis* differs from *V. bengalensis* by the flat dorsal surface of septomaxilla whereas in *V. bengalensis* this dorsal surface is concave with a very distinct crest emarginating the lacrimal duct and extending as far as the posterior border of the bone. The medial process of the remaining representatives of the genus *Varanus* is either distinctly shorter or the lateral process is only slightly developed (Mertens 1942). Although the rostral process of the septomaxilla is damaged in *V. mokrensis*, it may be estimated that it was shorter compared with that in extant specimens of *V. bengalensis* (e.g., MNHN 1884-4; SMF 60428) (see also Bahl 1937; Mertens 1942; Bellairs 1949). The short septomaxilla indicates that the snout portion of the skull of *V. mokrensis* was probably relatively short similarly to that of *V. olivaceus* (UF 57536; SMF 72156), *V. flavescens* (UF 64743; SMF 11546) and especially extant Australian varanids of the subgenus *Odatia* (Böhme W. 2003; Mertens 1942: 156-158).

- 2) The frontal and anterolaterally-directed postorbital processes of postorbitofrontal form an obtuse angle. *Remarks:* The postorbitofrontal is not preserved in other extinct species. In extant species, an obtuse angle between the frontal and anterolaterally-directed postorbital process of the postorbitofrontal occurs in *Varanus olivaceus* (SMF 72156), *V. salvadorii* (SMF 58064) and Australian *V. mertensi* (SMF 53275) and *V. giganteus* (SMF 53263). The postorbitofrontal of *V. mokrensis* differs from those in above mentioned species by the distinctly sharper angle between the parietal and squamosal processes of the postorbitofrontal.
- 3) The posterior margin of the nasal lobe of the frontal is situated in mid-way of rostral process with. *Remarks:* In extinct *V. darevskii* the nasal lobe is situated at the medial margin of the bone. Moreover, the frontal narrows in the middle of the orbit length

(Levshakova 1986) unlike *V. mokrensis*. The nasal lobe of the massively built frontal of extinct *V. priscus* is also situated in the mid-way of the rostral process width. However, the frontal of *V. priscus* is short and laterally wide with the prominent sagittal crest along the median suture between the frontals (Molnar 1990) contrary to *V. mokrensis*. In all remaining six extinct species, the frontal is not preserved. In extant species, the nasal lobe situated in mid-way of rostral process width occurs in adult specimens of *Varanus salvator* (e.g., BMNH 64.9.2.77), *V. jobiensis* (SMF 75817), and *V. olivaceus* (SMF 72156). However, *V. mokrensis* differs from *V. salvator* by the distinctly narrower posterior half of the bone. In *V. jobiensis*, the facet for contact with prefrontal is situated far from the facet for contact with the postorbitofrontal and the lateral descending process is massively built if compared with *V. mokrensis*. In *V. olivaceus*, the frontal is relatively wide and short in contrast to *V. mokrensis*.

- 4) The posterior margin of the anteroposteriorly enlarged frontal is narrow. *Remarks:* The same condition occurs in extinct *V. darevskii* which differs from *V. mokrensis* by the medial position of the nasal lobe and frontal constriction in the middle of the orbit. In *V. priscus*, the posterior margin of relatively short and massively built frontal is distinctly laterally wide contrary to slender frontal of *V. mokrensis*. The narrow posterior margin of the anteroposteriorly enlarged frontal occurs in extant *Varanus indicus* (SMF 11635), *V. doreanus* (SMF 33290) and Australian *V. gilleni* (SMF 11627) and *V. gouldii gouldii* (SMF 59018). In the frontal of *V. indicus*, the axis of the relatively short nasal lobe is directed posterolaterally in contrast to the posteriorly-directed nasal lobe in *V. mokrensis*. *Varanus mokrensis* differs from *V. doreanus* by the more distinctly developed nasal lobes whereas nasal lobes in *V. doreanus* are markedly short. The body of the frontal is clearly narrower in *V.*

*gilleni* and *V. gouldii gouldii* if compared to *V. mokrensis*. The frontal of *Varanus mokrensis* is particularly similar to that of *V. bengalensis* (Mertens 1942, tab. 22: 160, 161; SMF 60428; MNHN 1886-649), although the body of the bone is more slender in *V. mokrensis*. In *V. mokrensis*, the posterior margin of the nasal lobe is situated in the **mid-way along the rostral process width**. In adult specimens of *V. bengalensis*, the nasal lobe occurs close to the lateral margin of the rostral process (MNHN 1886-649). The posterior margin of the frontal of *V. mokrensis* is relatively narrow, if compared with *V. bengalensis* (MNHN 1886-649; Mertens 1942, tab. 22: 160, 161).

- 5) Parietal with wide, roughly rectangular fronto-postfrontal processes, anteriorly arched fronto-parietal suture and with **the** parietal foramen situated **posteriorly** far from **the** anterior margin of bone (more than **one third** of **the** parietal plate length). *Remarks:* Regarding extinct species, parietal is known in *V. darevskii*, *V. rusingensis*, *V. hooijeri* and *V. priscus*. *V. darevskii* lacks wide fronto-postfrontal processes. *Varanus rusingensis* (and possibly *V. hooijeri*) has developed wide fronto-postfrontal processes; however, both species differ from *V. mokrensis* by the much more developed constriction of converging parietal crests. *Varanus priscus* differs from *V. mokrensis* by much larger dimensions, more slender fronto-postfrontal processes, presence of straight frontoparietal suture, and parietal foramen situated close to the anterior margin of the bone (Molnar 1990). Regarding extant species, the wide roughly rectangular fronto-postorbitofrontal process of parietal occurs only in *Varanus bengalensis* (e.g., SMF 63456), *V. flavescens* (e.g., SMF 11546) and *V. rudicollis* (e.g., SMF 59216). All above mentioned species possess a straight frontoparietal suture whereas in *V. mokrensis* this suture is arched anteriorly. *Varanus mokrensis* further differs from *V. bengalensis* by the greater

distance between medially converging parietal crests. The shortest distance between medially converging parietal crests is situated very close to the posterior border of the parietal plate in *V. flavescens* contrary to *V. mokrensis* in which this constriction is shifted to the posterior fourth of the parietal plate length. Moreover, the parietal foramen is situated more anteriorly in *V. flavescens* if compared to *V. mokrensis*.

- 6) Distance between medially converging parietal crests of **the** parietal is the shortest in **the** posterior fourth of **the** parietal plate. *Remarks:* The distance between supratemporal fossae (measured at the level of the narrowest portion of **the** parietal), in the posterior fourth of the parietal plate, is distinctly shorter in *Varanus mokrensis* **in contrast** to extinct *V. darevskii* (Levshakova 1986: 104, fig. 2), but not as short as in extinct *V. rusingensis* (Clos 1995: 256, fig. 1A), *V. hooijeri* (Brongersma 1958: Plate IV/1) and *V. priscus* (Molnar 1990: 440, fig. 2C, D). The same distance between medially converging parietal crests as observed in *V. mokrensis* occurs in extant *V. griseus* (Mertens 1942, tab. 22: 162; NMP6V 22180; NMP6V 22948; NMP6V 22181; MNHN 1895-366) and *V. rudicollis* (SMF 59216; SMF 67586). *Varanus mokrensis* **differs substantially** from *V. griseus* by the presence of **a** wide roughly rectangular fronto-postorbitofrontal process which is narrow in *V. griseus* and by the narrower and anteriorly arched margin of frontoparietal suture. The frontoparietal suture is straight in *V. rudicollis*.
- 7) Otoccipital with very distinct occipital crest at base of **the** paroccipital process. *Remarks:* Regarding extinct species, the otoccipital is known only in *V. amnhophilis* and *V. priscus*. In *Varanus mokrensis*, the paroccipital process of the otoccipital is relatively long and massively built with **a** distinctly **ventrally** enlarged distal termination which is similar to that of extinct *V. amnhophilis* (Conrad *et al.* 2012: 5, fig. 2G-I). In *V. priscus*, the otoccipital is rather fragmentary with **a** broken distal

termination (Head *et al.* 2009: 448, fig. 1). Both extinct species lack the distinct depression on the dorsal surface of the paroccipital process which is conversely present in *V. mokrensis*. The massively built and distally enlarged paroccipital process of the otoccipital occurs in extant Asiatic varanids of the *V. bengalensis* group, in particular to *V. bengalensis* (e.g., MNHN 1886-649; MNHN 1884-4) and *V. flavescens* (e.g. UF 64743), as well as *V. salvator* (BMNH 1961.1761), *V. olivaceus* (e.g. UF 53917), and *V. salvadorii* (SMF 67670). However, the depression at the dorsal surface of the paroccipital process is never as distinct as in *Varanus mokrensis*. Moreover, the ~~elongate and prominent posteriorly situated~~ occipital crest in *V. mokrensis* ~~is is long and~~ directed distinctly lateroventrally and is straight ~~throughout along the~~ most of its length ~~as well~~. ~~These features are not present in extant representatives~~ of the genus *Varanus*.

- 8) Pointed conical teeth with distally recurved apices and prominent smooth mesial and distal cutting edges. *Remarks:* The distinct and smooth mesial and distal cutting edges in pointed teeth do not occur in extinct *V. rusingensis*, *V. hooijeri*, *V. priscus* (Clos 1995; Brongersma 1958; Anderson 1930; Hecht 1975) as well as in *Varanus* sp. from Gratkorn (Böhme & Vasilyan 2014). In the remaining extinct species the teeth are unknown. As regards extant species, the smooth cutting edges occur in several species of subgenera *Odatria* Gray, 1838, *Empagusia* Gray, 1838, and *Varanus*: *V. (Odatria) timorensis* (Gray, 1831), *V. (O.) tristis* (Schlegel, 1838), *V. (O.) eremius* Lucas & Frost, 1895, *V. (O.) caudolineatus* Boulenger, 1898, *V. (Empagusia) nebulosus* (Gray, 1831), *V. (E.) rudicollis* (Gray, 1845), and *V. (V.) giganteus* (Gray, 1845). *V. mokrensis* differs from above mentioned *Varanus (Odatria)* species by the ~~anteroposteriorly~~ wider base of the subrectangular frontal-postorbitofrontal process of the parietal and distinctly higher parietal roof width to

narrowest portion of parietal roof ratio. *V. mokrensis* differs from *Varanus* (*Empagusia*) species in its distinctly shorter septomaxilla; moreover, the parietal roof of *V. (E.) rudicollis* is **laterally** wide and **anteroposteriorly** short relative to that of *V. mokrensis*. The new taxon differs from *V. (V.) giganteus* in the shortest distance between the medially converging parietal crests in the posterior one-fourth of the parietal plate, whereas in *V. (V.) giganteus* the same constriction is situated much more anteriorly (SMF 53263).

- 9) **Trunk vertebrae** with moderately developed depression between pars tectiformis and medial margin of prezygapophyses and posterolaterally directed postzygapophyses which form a right angle. *Remarks:* The trunk vertebrae have distinctly smaller dimensions compared with those of extinct *Varanus amnhophilis*, *V. marathonensis*, *V. sivalensis* and *V. priscus*. The precondylar constriction (81% of the condylar width, n = 9) is less distinct compared with *V. amnhophilis* (75% in the first and 77% in the second preserved dorsal vertebra; Conrad *et al.* 2012), *V. hofmanni* (78%, type specimen NMA 86-471), and *V. rusingensis* (78%, n = 7; Clos 1995). Moreover, *V. mokrensis* exhibits postzygapophyses that are narrow compared with the prezygapophyses, in contrast to the conditions in *V. sivalensis* and *V. marathonensis* (Hocknull *et al.* 2009; Fejérváry 1918; Rage & Sen 1976). *Varanus mokrensis* differs from extinct *V. hofmanni* and *Varanus* sp. from Gratkorn (Böhme & Vasilyan 2014) by the less markedly developed depression between the pars tectiformis and the medial margin of the prezygapophyses as well as by the posterolaterally-directed postzygapophyses which delimit a right angle. Regarding extant species, the trunk vertebrae of *V. mokrensis* closely resemble those of *V. griseus* (NMP 22180, 22181 NMP) by the width of pre- and postzygapophyses and angle, which together form left and right postzygapophysis. However, the posterior

part of the neural arch of the extant *V. griseus* rises less conspicuously than that of *V. mokrensis*.

- 10) Praeacetabular process of the ilium prominent and directed at a right angle to the pubic process. *Remarks:* Regarding extinct taxa, the ilium is known only in *V. rusingensis* (Clos 1995: 256, fig. 1E) and *V. priscus* (Hecht 1975: 243-244). *V. rusingensis* differs from *V. mokrensis* by the less massively built and much more anteriorly inclined praeacetabular process. In *V. priscus* this process is very long, knob-like and oriented horizontally unlike *V. mokrensis*. The prominent praeacetabular process of ilium, which is directed anterodorsally rather than anteriorly and forms a right angle to the long pubic process, is known in extant Asiatic *Varanus bengalensis* (MNHN 1886-649) and Australian *V. varius* (Shaw, 1790); MNHN 1851-853. *Varanus bengalensis* differs from *V. mokrensis* in the absence of a distinct and very long bifurcated iliac crest. In *V. varius* the acetabular part of the ilium is much smaller than that of *V. mokrensis*.
- 11) Bifurcated iliac crest prominent. *Remarks:* In *V. rusingensis* and *V. priscus*, the bifurcated iliac crest is absent. Moreover, the excavation situated on the inner surface below the iliac crest is prominent in *V. rusingensis* whereas in *V. mokrensis* this excavation is shallow. Regarding extant representatives, the distinctly developed bifurcated iliac crest is absent in *Varanus bengalensis* (MNHN 1886-649). In *V. varius*, the acetabular part of the ilium is much smaller compared with *V. mokrensis*.

### **Body size estimation**

The average PCL/DVL for extant Indo-Asiatic A clade of *Varanus* (Conrad *et al.* 2012: table 1) is 36.22 (SD of 2.562; y intercept [yi] = 42.21; x intercept [xi] = -64.96;  $R^2 = 0.994$ ). If *V. mokrensis* is scaled similarly to other ‘Indo-Asiatic A’ - clade (Ast 2001) *Varanus*, we estimate (Fig. 8) its length as 374.9 mm ( $\pm 19.94$  mm with a 95% confidence interval) based on the length of the posterior dorsal vertebra (DVL). Based on the data concerning extant representatives of *Varanus* (Pianka *et al.* 2004; Conrad *et al.* 2012: table 2), *V. mokrensis* was a medium-sized monitor.

### Phylogenetic analysis

The complete list of characters and character states are reported in Appendices I and II (online supplementary material). We analysed 449 morphological characters coded for 87 taxa. The coding comes from Conrad *et al.* 2012. Safe taxonomic reduction identified six ‘unstable’ taxa, including five species of *Varanus* present in Conrad *et al.*’s (2012) analysis, namely: B. Qarun, *V. bivittatus*, *V. cf. marathonsensis* (topotypic fragmentary skull where a possible association with the holotypic vertebra needs a revision – Rage & Sen 1976; Estes 1983; Conrad *et al.* 2012), *V. keithornei*, *V. marathonsensis* (holotypic trunk vertebra – Rage & Sen 1976; Estes 1983), and *V. panoptes horni*. These taxa were excluded from the maximum parsimony analyses. Maximum parsimony analyses were terminated when a maximum of 50,000 trees were obtained. The unweighted analysis yielded hardly any resolution. The reweighted strict consensus of 3136 trees shows very poor resolution within the *Varanus* clade (Fig. 9) with the only exception being a relatively well supported Indo-Australian *Odatria* clade. Although the topology of the reweighted majority consensus tree derived from the reweighted analysis also showed poor resolution (Fig. 10), it showed that most extant

African species, together with the extinct *V. rusingensis* ~~reported~~ from the early Miocene (MN 3 Zone) of Kenya (Clos 1995), belong to a well supported (but rather unresolved) clade. ~~This clade which informs~~ the sister group to the extant *V. rosenbergi*. *V. mokrensis* is a member of a lineage ~~that is~~ ancestral to most African species, including *V. exanthematicus*, *V. ornatus*, *V. niloticus*, and *V. albigularis*. As regards ~~the~~ results of ~~the~~ Bayesian analyses (Fig. 11 and 12), ~~the Bayesian analysis run that employed with~~ gamma rates (Fig. 12) ~~showeds~~ generally better resolution, with a relatively well supported Indo-Australian clade as well as ~~an Indo-Asiatic~~ A clade (see Ast 2001), including a well-supported *Soterosaurus* clade.

Bayesian analyses run with equal and gamma rates show *V. mokrensis* to be a member of the extant representatives of the Indo-Asiatic A clade of *Varanus* with close affinities to the *V. bengalensis* species group (*Empagusia* clade; see Böhme W. 2003 and Koch *et al.* 2013). The topology of the Bayesian tree using both rate types supports the hypothesis that Miocene monitors from Mokr are representatives of a lineage ancestral to the extant African varanids plus the early Miocene *V. rusingensis* (Fig. 11 and 12). There are six well documented trans-Tethyan mammal dispersal phases between Eurasia and Africa throughout the Paleogene with the last important dispersal phase (from Laurasia to Africa) at the Priabonian/Rupelian boundary (Gheerbrant 1987, 1990, 2001; Gheerbrant & Rage 2006). It is possible that the first representatives of varanids might have dispersed into Africa from Eurasia as early as the late Eocene, i.e. long before the initial rifting and formation of the Eritrean Red Sea in the late Oligocene (27.5–23.8 Ma; Bosworth *et al.* 2005). This assumption is supported by the fact that most of outgroup members of the genus *Varanus* come from the Eurasia. The oldest known varanids with possible affinity to African monitors are known from isolated vertebrae from the late Eocene Birket Qarun Formation (Holmes *et al.* 2010)

and the early Oligocene Jebel Qatrani Formation, both in the Fayum Province, Egypt (*Varanus* stem-clade probably closely related to *Saniwa*; Smith *et al.* 2008). Although findings of the late Eocene varanids coincide with nuclear DNA estimates of the origination of *Varanus* (40.1 Ma; Portik & Papenfuss 2012), the phylogenetic position of these taxa is uncertain (Fig. 11 and 12; Conrad *et al.* 2012). It is plausible that the radiation of Eurasian varanids into Africa continued throughout the Oligocene, and multiple colonization events of Africa (probably via the Arabian Peninsula) cannot be excluded. The position of the early Miocene (~17–18 Ma; Sabol *et al.* 2007) *V. mokrensis* in the Bayesian analysis (particularly with the gamma rate), as well as the phylogenetic position and approximate age of the extinct African *V. rusingensis* (~20 Ma; Clos 1995; Fig. 11) partly support the hypothesis that the extant African species may have originated in the late Oligocene. The radiation of the African varanids might have continued throughout the Miocene, dotted by partial reverse routes into the Arabian Peninsula, as suggested by the position of *V. yemenensis* (Portik & Papenfuss 2012). However, the Bayesian analysis with gamma rates, where the extinct *V. rusingensis* occurs in a terminal position (Fig. 12), reveals that the diversification of the African varanid clade might have been completed as early as the early Miocene. In addition, the dispersal of North African varanids into Iberia is unlikely, given that the accurately dated North African-Iberian dispersal of mammals (6.2 Ma) via ephemeral land bridges in the Strait of Gibraltar occurred long before the onset of the Messinian Salinity Crisis (5.59 Ma) resulting from the latest Miocene glaciation at 6.26 Ma (Gibert *et al.* 2013). The only known late middle Miocene varanid, an as yet unpublished *Varanus* form from the Vallès-Penedès Basin in Catalonia (Spain) possibly referable to *Varanus marathonsensis* (Delfino *et al.* 2011), is most probably of Eurasiatic origin as is

*V. amnhophilis* reported from the late Miocene (7.6–6.9 Ma) of Samos, Greece (Fig.10; Conrad *et al.* 2012).

## Palaeoclimate

The amphibian and reptile assemblage from the 1/2001 Turtle Joint and 2/2003 Reptile Joint is rather diverse (Ivanov *et al.* 2006; Ivanov 2008, 2009). Based on Böhme *et al.* (2006), different ecophysiological groups occur in the early Miocene of Mokra-Western Quarry (tab. 1).

The herpetofauna of the Mokra-Western Quarry corresponds to the warm humid phase of the MCO (Miocene Climatic Optimum *sensu* Böhme M. 2003) during the early Miocene when mean annual temperatures (MAT) in Central Europe reached about 20 °C. In the North Alpine Foreland Basin (NAFB), the occurrence of cordylid lizards indicates MAT > 17.4 °C (Böhme M. 2003). Similarly, the presence of boid snakes with *Bavarioboa cf. hermi* Szyndlar & Schleich, 1993 in the southern part of the Moravian Karst (1/2001 Turtle Joint; 2/2003 Reptile Joint) also indicates a rather high MAT. The large boid snake from Mokra-Western Quarry (Boidae gen. et sp. indet., large form), probably belonging to Pythonidae, is important because Central European representatives of this family Fitzinger, 1826 are known so far only from the Griesbeckerzell, Germany (late MN 5 and base of MN 6). Pythons represent the most thermophilic members of the Squamata in the Miocene of Europe and document MAT > 18.6 °C (Ivanov & Böhme 2011).

Regarding humidity, there is a difference in the MAP (mean annual precipitation) between the two karst fissures. While the assemblage composition in the 1/2001 Turtle Joint indicates MAP = 461 ± 253 mm, the assemblage in the 2/2003

Reptile Joint indicates MAP =  $864 \pm 254$  mm (tab. 1). The amphibian and reptile assemblage of the 1/2001 Turtle Joint, where heliophobic taxa are absent altogether, developed in a relatively drier phase of the MCO when MAP values were comparable with today's long-term average value for this area (MAP = 490.1 mm – [www.chmi.cz](http://www.chmi.cz)).

### **Palaeoenvironment**

Remains of fully aquatic amphibians in the Karst fissures suggest the possible presence of nearby lacustrine environments. The absence of ostracods and the scarcity of gastropods indicates oligotrophic to weakly mesotrophic conditions (Ivanov *et al.* 2006). The diverse amphibian fauna (tab. 1, Ivanov *et al.* 2006; Ivanov 2008) includes *Mioproteus* sp., *Triturus* aff. *roehrsi* Herre, 1955, *Triturus* cf. *marmoratus* (Latreille, 1800), *Triturus* sp., *Chioglossa meini* Estes & Hoffstetter, 1976, *Mertensiella mera* Hodrová, 1984, *Mertensiella* sp., *Rana* sp. (synklepton *R. esculenta* Linnaeus, 1758). Among amniotes are turtles of the families Testudinidae Batsch, 1788 and Geoemydidae Theobald, 1868 (*Testudo* sp., *Ptychogaster* sp.; Luján – personal communication) and squamate reptiles (*Natrix* sp.). This assemblage indicates the presence of damp and marshy habitats with stagnant or slow flowing waters in both localities of the Mokrý-Western Quarry. However, species adapted to more humid terrestrial environments are also recorded, such as *Chelotriton* sp. whose adults probably inhabited damp habitats with dense vegetation (Estes 1981). This is inferred from the known habitat preferences of the closely related extant *Tylostotriton* Anderson, 1871 which usually inhabits humid high mountain areas with dense vegetation, although adults of this species are known to cover distances of several tens of meters away from water reservoirs (Kuzmin *et al.* 1994). Although the development of amphibians is

partly associated with aquatic habitats, the extinct pelobatid frog *Pelobates sanchizi* Venczel, 2004 was probably adapted to the dry sandy soil and well drained substrates within inundation areas (Venczel 2004; Böhme & Vasilyan 2014). *Bufo* sp. is also adapted to drier conditions. Squamates belong to semiaquatic/heliophilic forms (*Natrix* sp.) and to heliophilic, fossorial or terrestrial forms, such as cf. *Blanus* sp., *Varanus* sp., *Pseudopus* sp., *Lacerta* sp., type I, *Lacerta* sp., *Bavarioboa* cf. *hermi*, and 'Coluber' sp., type I, and *Vipera* sp. ('Oriental vipers' and 'European vipers'). Although the fillings of both karst fissures are approximately coeval (Ivanov *et al.* 2006), the scarcity or absence of certain aquatic or heliophobic forms of amphibians at the site 1/2001 Turtle Joint (rare occurrence of the genus *Triturus* Rafinesque, 1815, the absence of the genera *Chioglossa* Bocage, 1825 and *Mertensiella* Wolterstorff, 1925) indicates drier conditions (Ivanov 2008). This assumption is confirmed by the relatively higher proportion of 'Oriental vipers' in the faunal assemblage from this fissure.

The conclusions of our study are fully consistent with results of analyses of medium- and small-sized mammals (Ivanov *et al.* 2006; Sabol *et al.* 2007), the occurrence of which indicates a warm climate with a diverse mosaic of vegetation cover, possibly indicating open steppe and open forest environments with a system of rivers and swamps (Sabol *et al.* 2007).

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## FIGURE LEGENDS

**Figure 1. A**, Position of the locality Mokrá-Western Quarry (modified after <http://www.mapy.cz>). Position of the 1/2001 Turtle Joint and the 2/2003 Reptile Joint is indicated by an asterisk. Numbered circles indicate positions of Mokrá boreholes. **B**, European localities with fossil monitor lizards: 1 – San Roque, MN 3; 2 – Artenay, MN 4a; 3 – Petersbuch 2, 8, 28, MN 4a; Petersbuch 5, 36, MN 4; Petersbuch 41, MN 5; Petersbuch 39, 68, MN 6; Petersbuch 31, MN 7; Petersbuch 18, MN 8-9; 4 – San Marcos, MN 4; 5 – Córcoles, MN 4; 6 – Béon 1, MN 4; 7 – Erkerthofen, MN 4b; 8 – Vieux-Collonges, MN 4/5; 9 – Amor, MN 5; 10 – Las Umbrias 12, 18, 19, MN 5, Las Umbrias 11, MN 6; 11 – Vargas 11, MN 5; 12 – Villafeliche, MN 5; 13 – Ziemetshausen, MN 5; 14 – Gisseltshausen 1b, MN 5; 15 – Toril 3B, MN 6; 16 – Unterzell, MN 6; 17 – Stätzling, MN 6; 18 – Laimering, MN 6; 19 – Hohenraunau b. Krumbach, MN 6; 20 – Litke, MN 6; 21 – Subpiatră, MN 6; 22 – La Grive, MN 7+8; 23 – Gratkorn, MN 7+8; 24 – Varnitza, MN 9; 25 – Kalfa, MN 9; 26 – Bujor, MN 9b; 27 – Can Llobateres, MN 10; 28 – Cerro de los Batallones, MN 10; 29 – Kohfidisch, MN 10/11; 30 – Samos 1, MN 11; 31 – El Arquillo, MN 13; 32 – Cava Monticino, MN 13; 33 – Verduno, MN 13; 34 – Cherevichnoie, MN 13; 35 – Moreda a, MN 15; 36 – Layna, MN 15; 37 – Sète, MN 15; 38 – Balaruc 2, MN 15-MN 16; 39 – Pikermi, MN 16; 40 – Beremend, MN 16; 41 – Csarnóta, MN 16; 42 – Tourkobounia 5, Middle Pleistocene. A – modified from Ivanov *et al.* (2006); B – data according to Roger (1898, 1900), Hoffstetter (1969), Alférez Delgado & Brea López (1981), Antunes & Mein (1981), Antunes & Rage (1974), Böhme & Ilg (2003), Hír & Venczel (2005), Rage & Bailon (2005), Ivanov *et al.* (2006), Tempfer (2005), Venczel (2006), Ivanov (2009), Conrad *et al.* (2012), Delfino *et al.* (2013a, b), Böhme & Vasilyan (2014), Colombero *et*

*al.* (2014), Venczel & Hír (2015), Pérez-Ramos *et al.* (2016) and Georgalis *et al.* (in press).

**Figure 2.** *Varanus mokrensis* sp. nov., **A, B**, Pal. 1023 (1/2001 Turtle Joint), fragmentary left maxilla in lateral (**A**) and medial (**B**) views; **C-E**, Pal. 1024 (1/2001 Turtle Joint), fragmentary rostral part of the left maxilla with preserved tooth in medial (**C**) and lateral (**D**) views and the tooth detail (**E**) with clearly developed keel without any trace of indentation; **F**, Pal. 1026 (1/2001 Turtle Joint), fragmentary right maxilla in medial view, the tooth base shows an advanced stage of resorption. **G, H**, snout of extant *Varanus bengalensis* (SMF 63456) in laterodorsal (**G**) and lateral (**H**) views. *Varanus mokrensis* sp. nov., **I, J**, Pal. 1020 (1/2001 Turtle Joint), left septomaxilla in dorsal (**I**) and ventral (**J**) views. **Abbreviations:** ant.smx.for, anterior septomaxillary foramen; cr.den, crista dentalis; dor.smx.for, dorsal septomaxillary foramen; ex.na, excavatio nasalis; fac.pr, facial process; fac.vo, facet for contact with vomer; fen.vo.ext, fenestra vomeronasalis exonaria; iorb.can, infraorbital canal; lab.fora, labial foramina; nar.mar, narial margin; smx.fo, septomaxillary fossa; sul.Va, sulcus for ophthalmic + ethmoidal nerve and ethmoidal artery; sup.sh, supradental shelf.

**Figure 3.** *Varanus mokrensis* sp. nov., **A, B**, Pal. 1117 (2/2003 Reptile Joint), left postorbitofrontal in dorsal (**A**) and ventral (**B**) views. **C**, left postorbitofrontal of extant *Varanus flavescens* (SMF 54157) in laterodorsal view; **D**, right postorbitofrontal of extant *Varanus bengalensis* (BMNH 1974.2479) in laterodorsal view. *Varanus mokrensis* sp. nov., **E, F**, Pal. 1090 (2/2003 Reptile Joint), left frontal in dorsal (**E**) and ventral (**F**) views; **G**, Pal. 1098 (2/2003 Reptile Joint), **H, I**, Pal. 1097 (2/2003 Reptile Joint), parietal in dorsal (**G, H**) and ventral (**I**) views. **Abbreviations:** arc.edg, arcuate

edge; cer.cav, cerebral cavity; cr.cra.fr, crista cranii frontalis; cr.cra.pa, crista cranii parietalis; fac.fr, facet for contact with frontal; fac.pa, facet for contact with parietal; fac.pfr, facet for contact with prefrontal; fac.pofr, facet for contact with postorbitofrontal; fac.sq, facet for contact with squamosum; fr-pa.su, fronto-parietal suture; fr-pofr.pr, frontalo-postorbitofrontal process; fr.pr, frontal process; na.lo, nasal lobe; pa.cr, parietal crest; pa.fo, parietal fossa; pa.for, parietal foramen; pa-pofr.pr, parietal-postorbitofrontal process; pa.pr, parietal process; por.pr, postorbital process; sq.pr, squamosal process; st.fo, supratemporal fossa; st.pr, supratemporal proces.

**Figure 4.** *Varanus mokrensis* sp. nov., **A, B**, Pal. 1134 (2/2003 Reptile Joint), left palatine in dorsal (**A**) and ventral (**B**) views. **C**, left palatine of extant *Varanus bengalensis* (SMF 63456) in ventral view. *Varanus mokrensis* sp. nov., **D, E**, Pal. 1131 (2/2003 Reptile Joint), right pterygoid in dorsal (**D**) and ventral (**E**) views; **F**, Pal. 1152 (2/2003 Reptile Joint), right quadrate in caudal view; **G, H**, Pal. 1104 (2/2003 Reptile Joint), right prootic in lateral (**G**) and medial (**H**) views. **I**, left prootic of extant *Varanus bengalensis* (SMF 63456) in lateral view. *Varanus mokrensis* sp. nov., **J-M**, Pal. 1109 (2/2003 Reptile Joint), left otoccipital in dorsal (**J**), caudal (**K**), cranial (**L**), and medial (**M**) views; **N**, Pal. 1014 (1/2001 Turtle Joint), basioccipital in ventral view.

**Abbreviations:** ant.sci.can, anterior semicircular canal; ar.con, articular condyle; bsph.pr, basisphenoid process; co.fo, columellar fossa; coch.cav, cochlear cavity; cr.al.pot, crista alaris prootica; cr.co.ant, crista columellaris anterior; cr.co.post, crista columellaris posterior; cr.pot, crista prootica; cr.tra.dor, crista transversa dorsalis; ect.pr, ectopterygoid process; fac.pr, facial process; fac.st, facet for contact with supratemporal; for.ro, foramen rotundum; hor.sci.can, horizontal semicircular canal; inf.pr.pot, inferior process of prootic; IX, foramen for glossopharyngeal nerve; mx.pr,

maxillary process; occo.tub, occipitocondylar tubercle; oc.cr, occipital crest; pal.pr, palatal process; paoc.pr, paroccipital process; post.cr, posterior crest of quadratum; post.pr.pot, posterior process of prootic; post.sci.can, posterior semicircular canal; pt.pr, pterygoid process; qu.pr, quadrate process; sph-oc.tub, sphenoccipital tubercle; sul.ve.jug, sulcus venae jugularis; suor.inc, suborbital incisure; sup.alv.can, superior alveolar canal; sup.pr.pot, superior process of prootic; tri.no, trigeminal notch; ty.fo, tympanic fossa; vest.cav, vestibular cavity; VII, foramen for the facial nerve; VII.pal, foramen for palatine branch of the facial nerve; vo.pr, vomerine process; X, foramen for vagus nerve; XI, foramen for accessory nerve; XII, foramen for hypoglossal nerve.

**Figure 5.** *Varanus mokrensis* sp. nov., **A-C**, Pal. 1114 (2/2003 Reptile Joint), basisphenoid in anterior (**A**), dorsal (**B**), and lateral (**C**) views; **D**, basisphenoid of extant *Varanus bengalensis* (MNHN 1886-649) in cranial view; *Varanus mokrensis* sp. nov., **E-G**, Pal. 1140 (2/2003 Reptile Joint), right dentary in lateral (**E**) and medial (**F**) views, a sharp mesial and distal carina is developed on the anteriorly situated tooth (**G**); **H-J**, Pal. 1144 (2/2003 Reptile Joint), almost complete left surangular in medial view broken on the two parts (**H**, **I**) and anterior part of surangular in lateral view (**J**); **K**, Pal. 1037 (1/2001 Turtle Joint), left surangular in medial view; **L, M**, Pal. 1150 (2/2003 Reptile Joint), right articular in medial (**L**) and dorsal (**M**) views. **Abbreviations:** al.pr, alary process of basisphenoid; aVc, anterior orifice of the Vidian canal; bcr.de, basicranial depression; bpt.pr, basiptyergoid process; car.can, carotid canal; cr.sel, crista sellaris; fac.art, facet for contact with articular; fac.cor, facet for contact with coronoid; fac.sur, facet for contact with surangular; for.ch.ty, foramen chorda tympani; for.dor.ma.n, foramen for re-entry of the dorsal branch of the mandibular nerve;

for.ma.cut.n, foramen for mandibular cutaneous nerve; fov.den, fovea dentalis; gl.fo, glenoid fossa; ma.can, mandibular canal; ma.for, mandibular foramen; me.gr, Meckel's groove; men.for, mental foramen; psph.pr, parasphenoid process; pVc, posterior orifice of the Vidian canal; ret.pr, retroarticular process; r.p, resorption pit; sel.tu, sella turcica; sub.sh, subdental shelf; VI.ant, anterior orifice of the canal for abducens nerve; VI.post, posterior orifice of the canal for abducens nerve.

**Figure 6.** *Varanus mokrensis* sp. nov., **A, B**, Pal. 1040 (1/2001 Turtle Joint), cervical vertebra in lateral (**A**) and caudal (**B**) views; **C, D**, Pal. 1159 (2/2003 Reptile Joint), cervical vertebra in lateral (**C**) and dorsal (**D**) views; **E-H**, Pal. 1172 (2/2003 Reptile Joint), anterior trunk vertebra in lateral (**E**), dorsal (**F**), ventral (**G**), and cranial (**H**) views; **I-M**, Pal. 1183 (2/2003 Reptile Joint), middle trunk vertebra in lateral (**I**), dorsal (**J**), ventral (**K**), cranial (**L**), and caudal (**M**) views; **N-P**, Pal. 1207 (2/2003 Reptile Joint), sacral vertebra in dorsal (**N**), ventral (**O**), and cranial (**P**) views; **Q**, Pal. 1066 (1/2001 Turtle Joint), sacral vertebra in ventral view; **R, S**, Pal. 1215 (2/2003 Reptile Joint), anterior caudal vertebra in dorsal (**R**) and ventral (**S**) views. **Abbreviations:** cd, condyle; ct, cotyle; hy, hypapophysis; na, neural arch; nc, neural canal; ns, neural spine; po, postzygapophysis; pof, postzygapophyseal articular facet; pr, prezygapophysis; prf, prezygapophyseal articular facet; syn, synapophysis; t.pr, transversal process.

**Figure 7.** *Varanus mokrensis* sp. nov., **A, B**, Pal. 1154 (2/2003 Reptile Joint), left ilium in lateral (**A**) and dorsal (**B**) views. **Abbreviations:** il.cr, iliac crest; is.pr, ischial process; pac.pr, preacetabular process; poac.pr, postacetabular process; pub.pr, pubic proces.

**Figure 8.** Body size estimation (SVL – snout-vent length) of *Varanus mokrensis* sp. nov. and *Varanus amnhophilis* (AMNH FR 30630) based on comparison of posterior dorsal vertebra length (DVL). The solid black trend line was calculated using extant species (see Conrad *et al.* 2012, table 1) from the ‘Indo-Asiatic A’ clade of *Varanus* (PCL/DVL, y intercept [yi] = 42.21, x intercept [xi] = -64.96,  $R^2 = 0.996$ ). Gray bars indicate predictive size range within 95 percent confidence interval; the vertical bars indicate predictive size range within 95 percent prediction interval.

**Figure 9.** Reweighted strict consensus tree.

**Figure 10.** Reweighted majority consensus tree.

**Figure 11.** The majority-rule of consensus topology used in the Bayesian analysis (without constrains). Bold – fossil varanids; † - extinct *Varanus* species; black dot – PP (posterior probability) 100%, remaining nodes 50%.

**Figure 12.** The majority-rule of consensus topology used in the Bayesian analysis (with character-state change probability). Bold – fossil varanids; † - extinct *Varanus* species; black dot – PP (posterior probability) 100%, remaining nodes 50%.

**Table 1.** Amphibians, turtles, and squamate reptiles from Mokrá – Western Quarry (1/2001 Turtle Joint and 2/2003 Reptile Joint), supposed ecophysiological groups, and calculation details for the estimation of palaeo-precipitation (according to Böhme *et al.* 2006; data modified from Ivanov 2008, 2009).