Histological analysis and comparison between bones of *Stephanorhinus kirchbergensis* from Gorzów Wielkopolski (Poland), woolly rhinoceros *Coelodonta antiqutitatis*, indian rhinoceros *Rhinoceros unicornis*, black rhinoceros *Diceros bicornis* and white rhinoceros *Ceratotherium simum* – preliminary data and perspectives

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Introduction.

During construction of express way S3 in April 2016 in the environs of Gorzów Wielkopolski a very well-preserved skeleton of rhinoceros was found. Preliminary taxonomical expertise based on the morphological structure of teeth showed that this specimen belong to genus *Stephanorhinus* (Kretzoi, 1942). Further analysis of morphology and osteometrical features indicates that it is most probably *Stephanorhinus kirchbergensis* (Jäger, 1839). This discovery was unexpected for a few reasons. Interglacial fauna in Poland is known mainly from cave sites and it usually contains of straight-tusked elephants and cervids (Jakubowski, 1996; von Koenigswald, 2007; Stefaniak, 2015). Findings of *Stephanorhinus* are not common either. Less than 10 findings were known from Poland up to last year, and only 5 skulls were found in Europe. Generally, the unearthed specimens were preserved poorly or represented only by isolated teeth. (Gürich, 1908; Czyżewska, 1962; Bilia & Petronio, 2009; Lacombat, 2009; Wiśniewski i in., 2009; Made van der, 2010; Bilia, 2011).

Stephanorhinus from Gorzów Wielkopolski is preserved very well – the state of it's remains enabled microscopic analysis of bones and comparison with four species from the same family (*Rhinocerotidae*): extinct woolly rhinoceros *Coelodonta antiquitatis* (Blumenbach, 1807) from several cave sites in Poland, and three extant species: white rhinoceros *Ceratotherium simum* Burchell, 1817, black rhinoceros *Diceros bicornis* L. 1758 , and Indian rhinoceros *Rhinoceros unicornis* L. 1758. Comparative material taken from said rhinos came from museal collections of University of Wrocław and Wrocław University of Environemental and Life Sciences. The other two extant species of rhinos, which are Javan *Rhinoceros sondaicus* Desmarest, 1822 and Sumatran *Dicerorhinus sumatrensis* (Fischer, 1814), are not investigated in this work due to the abscence of suitable material in a range of authors.

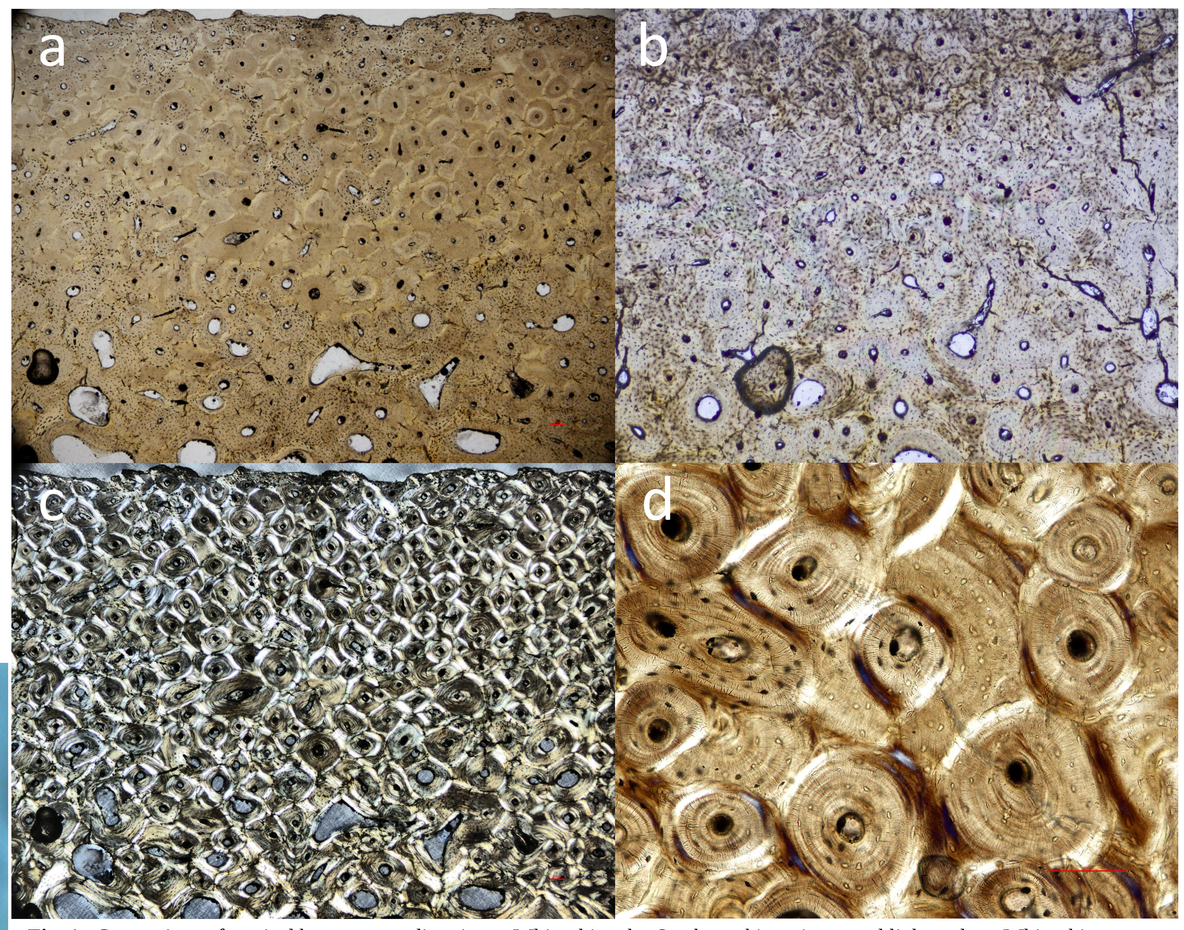

Fig. 1. Comparison of cortical bone metapodium in a – White rhino b– *Stephanorhinus* in normal light and c- White rhino d-– *Stephanorhinus* in polarised ligh. Note different porosity level in both cortical bones . Mag - a,b c 40x, d-200x
(Phot. Dariusz Nowakowski)

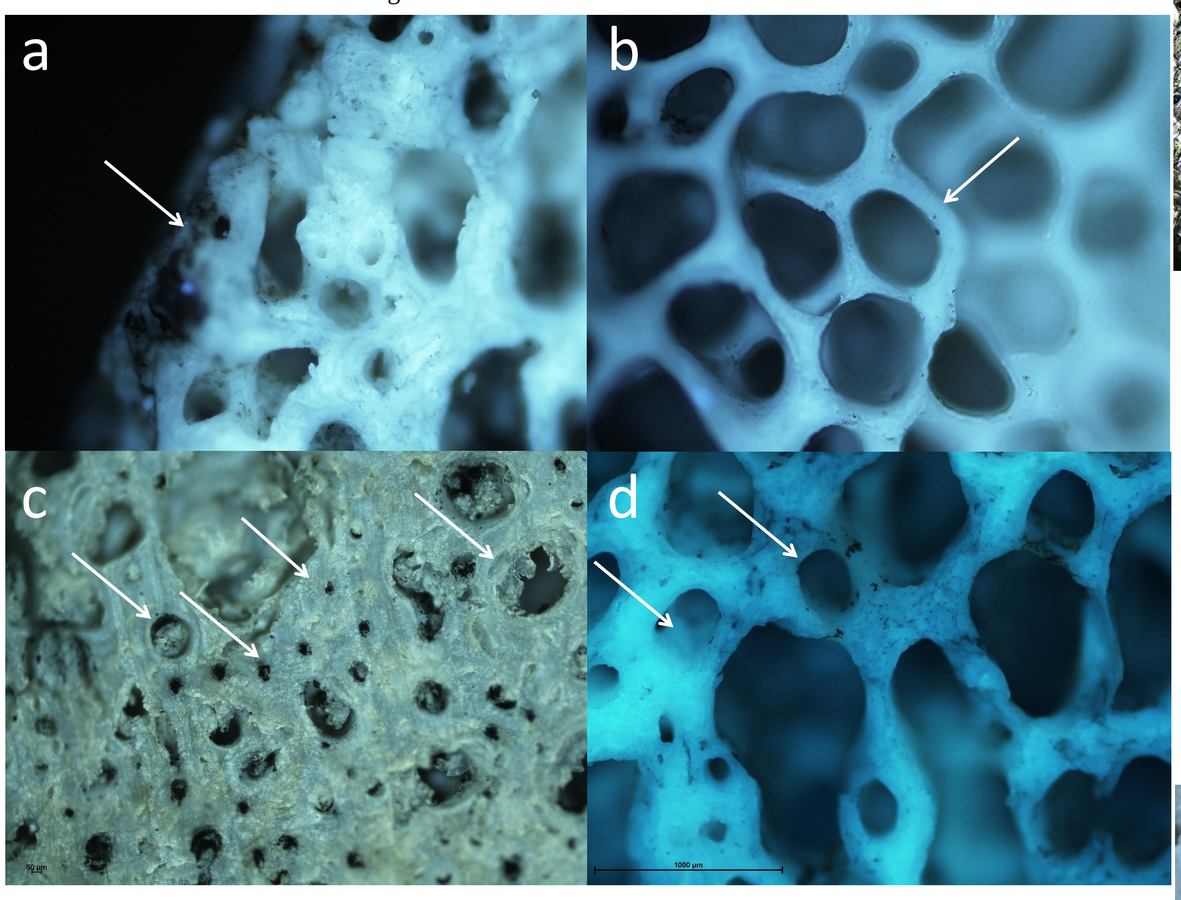

Fig. 2. a -*Coelodonta*. Metapodium, periosteum (arrow). Note the lack of the compact bone
b –*Coelodonta*. Metapodium, bone marrow. Spongy bone form oval-shaped tubules with moderate thickness wall (arrow).
c – *Stephanorhinus* Metapodium , bone cortex; High porosity of the compact bone. Numerous ostons of different size (arrow)
d –Indian rhino. Metapodium bone marrow. Thicker bone trabecules form tubules (arrow) Autofluorescence Mag 40x
(Phot. Karolina Kołaczyk, Adam Kotowski, Piotr Kuropka)

Results.

The first method showed that compact bone tissue of rhinos' is characterized by densly located osteons which are circular or eliptic in crossection. This indicates that specimens used in this analisys were fully grown and their bones were adapted to surpass vast compressig forces. As for now, it seems, that there is no significant statistical difference in average diameter of osteons between investigated species.

The second method showed that there are morfological differences in cortical parts of meatapodials and webbing of spongious bone tissue filling the medullar cavity, depending on the species. Spongious tissue is fomed in two ways: as trabecuale and as laminae. *S. kirchbergensis* and *C. simum* have well developed compact bone tissue in which trabeculae form tubes all along the long axis of bone, whereas *C. antiquitatis* lacks osteons. *D. bicornis* and *R. unicornis* show some transitional forms.

Statistically there is no significant difference in trabeculae's thickness in pairs *C. simum – D. bicornis* and *C. antiquitatis* - *R. unicornis. S. kirchbergensis* shows significant difference when compared to the rest. Distribution of trabeculae's thickness confirms those differences.

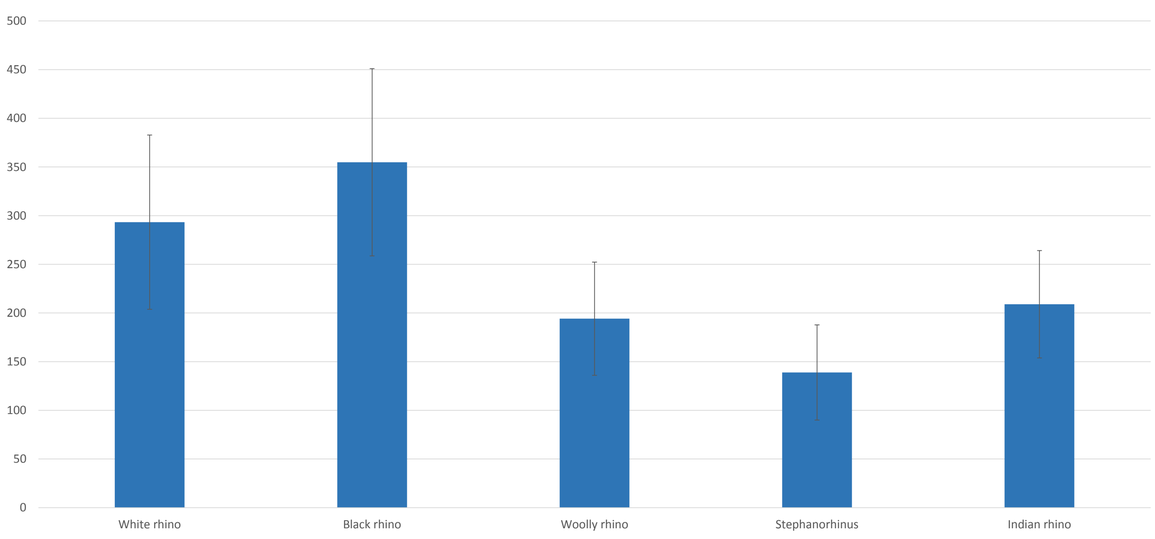

Fig. 4. Morphometry of bone trabecules thickness.
The analysis shows insignificant difference between Black and White rhino as well and between Woolly and Indian rhino.

Methods.

In the following work two methods were applied. Material consisted of metacarpal bones, radii, humeri, and ribs. Bones were cut with diamond saw. In the first method, obtained roundels were submerged in epoxyresin, divided in to parts having 2mm in thickness. Then microsections were obtained by polishing. After enclosure in DPX, observations were conducted in transmitted light and polarized light. Then diameters of osteons were measured. Minimum, maximum and standard deviation were calculated, and Student t-test was used to check if there was a statistical relations between averegae diameter of osteon among studied species.

In the second method, samples of the same material, without submerging in resins and polishing, were observed in fluorescent microscope using UV-2A filter. The main aim of the analysis was to measure the thickness of bone trabeculae. Afterwards the obtained data was statistically analized in way similiar to the first method.

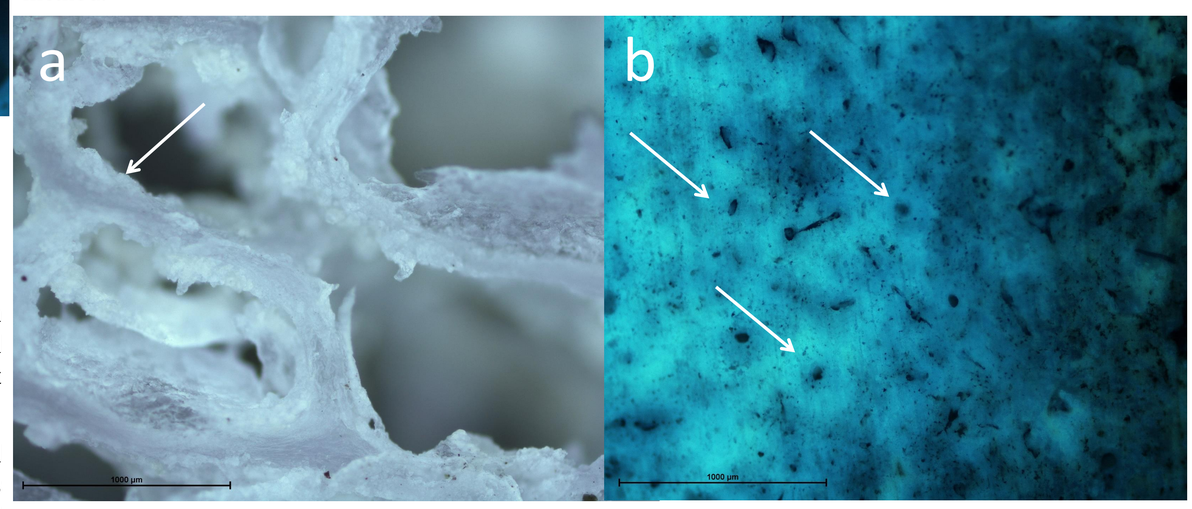

Fig. 3.
a- Black rhino. Metapodium bone marrow. Very thick bone trabecules covered by soft tissue (arrow)
b- Black rhino. Metapodium cortex . Numerous, regular large osteons (arrow) Autofluorescence Mag 40x
(Phot. Piotr Kuropka)

Perspectives.

Since postcranial anatomy of *Rhinocerotidae* is conservative, determining the species is often diffucult when it comes to isolated fossil material. It is probably common situation when e.g. metapodials of *Coelodonta antiquitatis* and *Stephanorhinus sp.* are mistaken. It is possible that further investigation in the matter of microscopic comparison between these two species may bring a method of distinguishing them properly.
Similarities of trabeculae structure seems to correspond with phylogeny of rhinos. This comparison may be of use in terms of further inquiry into origins and relationships of genus *Stephanorhinus.*

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