



European Taxidermy Championships® | Budapest 2021

**Orobates pabsti (BERMAN et al., 2004) &
Ichniotherium sphaerodactylum –
a glimpse of Permian terrestrial locomotion**



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Category: Scientific modelling (Master)





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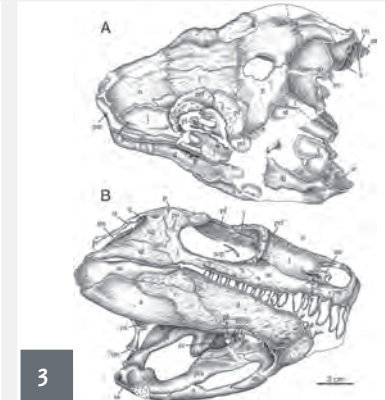


INTRODUCTION:

Orobates is an extinct genus of Diactectidae – an evolutionary family of vertebrates combining conservative amphibian and advanced reptil-like characteristics during middle Permian age about 260 million years ago. *Orobates pabsti* is known since 1998 from perfectly preserved fossils: a complete articulated skeleton and numerous fossilized footprints and track marks named *Ichniotherium sphaerodactylum* from the world famous sandstone quarry of Bromacker (Thuringia) in central Germany.

Bromacker quarry The combination of fossilized footprints together with complete articulated skeleton finds is unique worldwide. Other fossils of the same level show subterranean burrows which can also be assigned to *Orobates* (also as fossil traps for complete skeleton preservation inside). The Bromacker finds present a complex Ecosystem of the middle Permian age with a diverse fauna and flora of early terrestrial species. Its sand- and clay stones were sediment at continental high level plateau pervaded by periodical water streams, ponds and flood-lands. This Permian area far from the sea was characterized and formed by an extremely continental climate with hot day and cool night temperatures – it was the age of the single supercontinent Pangäa before it starts to crack and spread into the modern landmasses. Periodical temperatures below zero degrees Celsius are documented too – so that fauna and flora had to adapt on quite a lot climatic extremes into their functional anatomy to survive. The herpetofauna vertebrates of that time are called “Ursaurier” – also as there are not close ancestors or even relatives of the million years later evolving Dinosaurs – but they were the first documented real terrestrial vertebrates in evolution of life.

Material and Interpretation:



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Holotypus *Orobates pabsti*

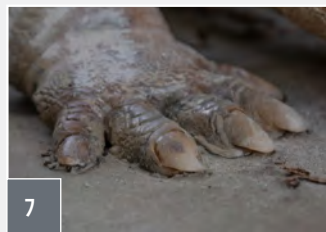
2
skull of Holotypus

3
skull of Paratypus

4, 5
hands and feet of Holotypus (cast)

6
a hand of a mole shows similar digging adaptations

7, 8
reconstructed hand and feet of *Orobates pabsti*



The Holotype skeleton and other fossils of *Orobates pabsti* (No. 10181) are stored at Museum der Natur Gotha (Thuringia, Germany). All anatomical measurements from this specimen were transferred in scale 1:1 to create the presented reconstruction model. It shows following features:



- a slender but strong torso
- a short but very strong neck with massive cervical muscles
- a compact ram-like skull with enforced rostrum, eye bulges, strong but shortened lower jaw
- an epigyneous mouth with strong stick-like teeth sparsely differentiated, arranged similar to rodents or other burrowing animals (almost vertical maxillary at upper jaw as abutment to diagonal - almost horizontal teeth of the lower jaw)
- an elongated tail with strong basal muscles for powerful lateral undulating moves
- short, large and powerful limbs with strong and flattened fingertips and toes
- toes and fingers show no pointed claws but flat fingernail like tips

9, 10

To reconstruct the volume of the fossilized torso the author adjusted his model according to how torso skeletons of modern reptiles change in shape after death. This two images show the same individual of a *Pogona barbata* corpus. Its obvious how ribs are pulled back to the spine after death and during drying - and so give a fake image of a very narrow torso which was very much larger during lifetime. The fossilized torso of *Orobates pabsti* (Holotypus) is deformed in a similar way - so this effect had to be equalized during reconstruction.



In addition several well preserved fossilized track-marks classified as *Ichniotherium sphaerodactylum* disclose exceptional further information about the quadrupedal locomotion of *Orobates*.



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Today reptiles do a centrifugal outside movement with its limbs – a kind of “throwing them” from front around the body and just behind them. It seems to be the common way of a typical reptiles walk.

Orobates had its unique way to walk, similar but not same to amphibians like *Salamandra* or newts. A first try of nature to evolve a permanent quadrupedal walk on land.

– The footprints by walking were set quite narrow in relation to the central body axis – more then it could be expected according to the measurements of the skeleton in comparison to a modern reptile as a crawler. That fact shows that the angles of elbows and knees had at least 90 degrees and so the body was held quite high up the ground without touching it with its belly. The spinal column of the torso was lifted from a straight position up to a slightly convex curve as modern caudates do.



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The footprints point out that while working hands and feet were turned body inwards in a partly rotational movement – a fact that is quite the opposite as the way modern reptiles walk.

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Footprints show marks of inside rotation, just opposite to modern reptiles

13

a walking commodo dragon throwing his limbs centrifugal outside



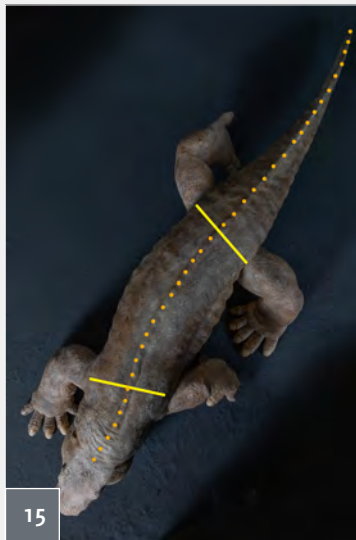
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- Also measurements between the footprints and central body axis indicate that the vertebra column of torso and also tail did serpentine undulating movements while walking. Further the shoulder girdle and pelvis were alternate rotating horizontal by doing step by step.

- A very interesting and until now sparsely noticed fact is that there are not any stress marks of the elongated tail in the fossilized soil. That proves the tail usually did not touch the ground while walking. This opens up the question of the anatomical structure and the function of that very huge part of the body. For the author it seems to be obvious that a round and lizard-like tail would hang down and grind the soil. So this lack of tail-marks could be a hint towards other functional structures like a strong cartilaginous seamed tail. There would be no difference in volumes - and so not in substantial weight - between a round or vertical flattened tail. But a vertical flattened cartilaginous rudder organ fits to the massive basal tail muscles for strong undulation movements. Also a vertical flattened tail like that would be much more vertical stable in it self against hanging down by walking.



15



16

- 14 angles of knees
- 15 Spinal undulations and alternating rotation of shoulder girdle and pelvis
- 16 a beavers tail beside the reconstructed *Orobates* tail
- 17 *Orobates* tail didn't touch the ground while walking



17

Reconstruction of *Orobates pabsti* in its ecosystem:

By putting all that facts and considerations together *Orobates pabsti* was an early experimental side way in evolution of early terrestrial vertebrates. He was something like a missing link between the modern classified amphibians and the so called reptiles. Following ideas seems to create an authentic image:

The Permian plains of Bromacker far from the sea had an extreme continental climate with hot days and cool nights. From neighboring eroding mountain ranges huge amounts of clay and sand were sediment by periodical streams caused by monsoon thunderstorms, rainfalls and also snow melts. Flat muddy rivers meandering into the plains forming flat ponds and shores. Also nutrients like drown insects, carrion and digestible parts of plants were washed up at the flat shores – a main and regular food resource for plants and animals living in that environment. Vertebrates like *Orobates* patrolled along that muddy shores collecting omnivorous food in the seams – and ate whatever they find. Also gymnosperm plants colonized the periodical flood lands. Their subterranean roots were also flushed out at the meandering river shores – a perfect spot for *Orobates* to dig in hunt of bulbs or insect larva and other invertebrate prey hidden inside.

The body of *Orobates pabsti* is anatomical adapted for digging into loose and medium solidified soil as sand and clay. The fossil reports of burrow structures can easily be connected to the anatomical specializations of flattened nails, strong and short limbs, short powerful neck and a ram-like head with a downward mouth with angular jaws and teeth of the animal itself. The deeper layers of the sediment probably provided moisture all over the year – also during dry seasons. *Orobates* could last inside own build burrows against deep temperatures, dryness, or lack of food – maybe also in a kind of hibernation sleep like a lung



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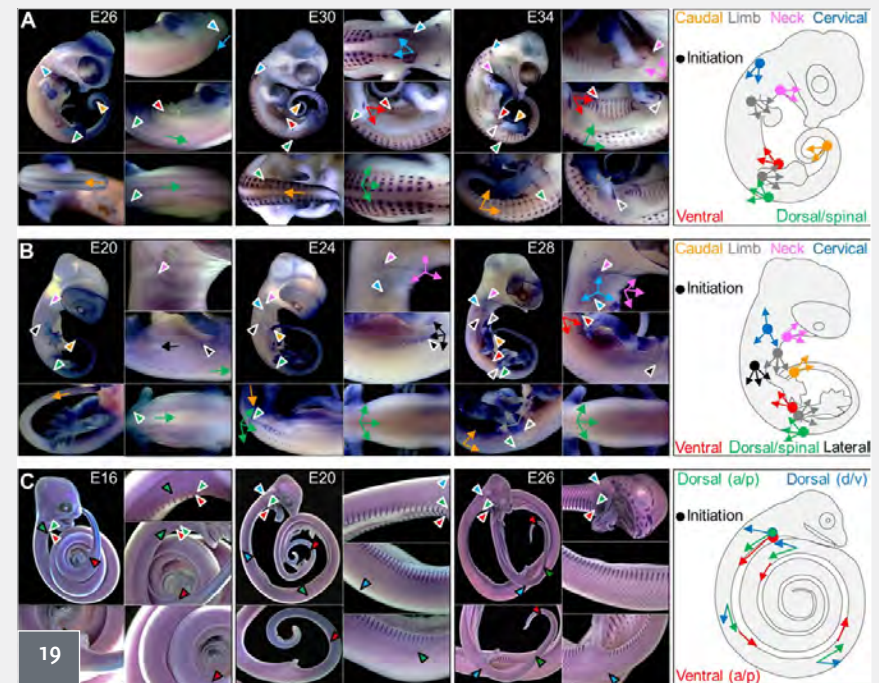
fish (*Neoceratodus*). Also its burrow was protective shelter against predators like *Dimetrodon* which had no anatomical adaptations for digging. It is also an realistic scenario that the outstanding articulated conservation of the *Orobates* Holotype is the result of a sudden flood burial of a resting animal inside its own build subterranean burrow (fossil trap).

Orobates probably had a specialized skin for that extreme periodical changing wet and dry, cool and hot environment. The lateral skin was maybe soft and lobed to provide an amphibian like skin respiration at moisture conditions (mud, burrow, dew). Beside that rather archaic elements the more exposed bodyparts probably had some new evolved features. To preserve against sun drying, irritations and injuries by digging in the ground – and also as protection against predator assaults like by *Dimetrodon* – *Orobates* was probably wearing ceratin-protoscales.

Before scales of fish and amphibians were of bone. There are no bony scales fossilized at *Orobates*. During the Permian age scales as body surface evolved once again as oval scales of ceratin. The evolution of ceratin-scales is less observed. A question that paleontologists sometimes failing to adhere according to theoretical taxonomic systematic. If a skeleton is classified as amphibian or reptile it should be important to think about what was happening in that age long times between the typical characteristics of that vertebrate class were evolved – an anatomical plan of a modern reptile or something like a ceratin scaled skin did not emerge suddenly or pop out of nothing. It probably was a slow process with several steps between an amphibian skin to one of a modern reptile. It is one purpose of this reconstruction model to show how such an animal “in between” could have looked like. To get an idea of the appearance of that early ceratin scales and to reconstruct an animal just during the long evolutionary process of ceratin scales the author observed images of so called scale placode of turtle and lizard embryos.

These atavistic structures are rounded ceratin shields embedded in skin which evolve during the ontogeny to typical scales. On that the author was inspired to create the presented homogeneous *Orobates* skin. Nails, fingers and toes and also the head were most exposed and stressed by walking and digging – so these parts were most ceratinized – almost like a real reptile, which of course *Orobates* was not.

About the function of the elongated tail it's conceivable that *Orobates* used its tail as rudder organ to take fast refuge into flat water ponds. Probably *Orobates* was usually patrolling around ponds looking for water driven food. If a predator like *Dimetrodon* took his track he could step into the water and with just one hit



of its powerful tail *Orobates* could swim or dive very fast into deeper water were he was save of terrestrial predators.

Some parts of this image of the living animal *Orobates pabsti* of course originate in model makers fantasy, but all of them correspond with the extracted information of the fossil report (skeleton, tracks, environment) at the actual state. It is an outstanding and complex amount of information about a lost animal in view to the unbelievable age of 260 million years of the Bromacker finds.



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