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Another glimpse of Permian terrestrial locomotion:  
*EUDIBAMUS CURSORIS* (David S. Berman et al.; 2000) - THE FIRST EVER BIPEDAL WALKER  
IN EVOLUTION OF LIFE



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Category: Scientific modelling (Master)





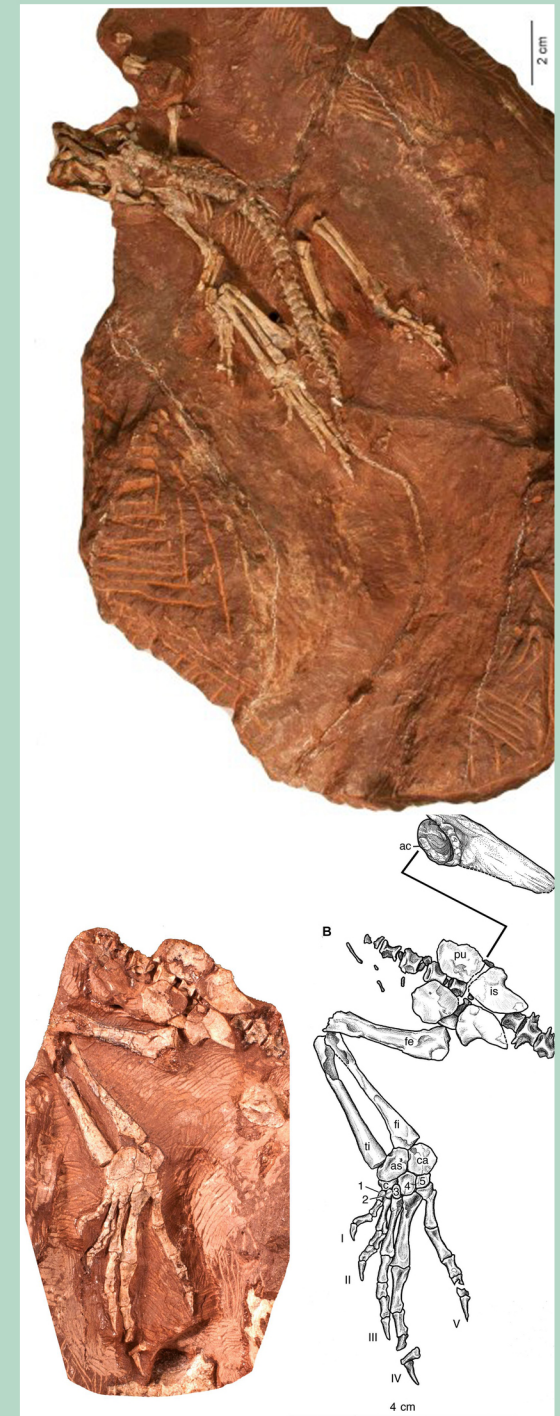
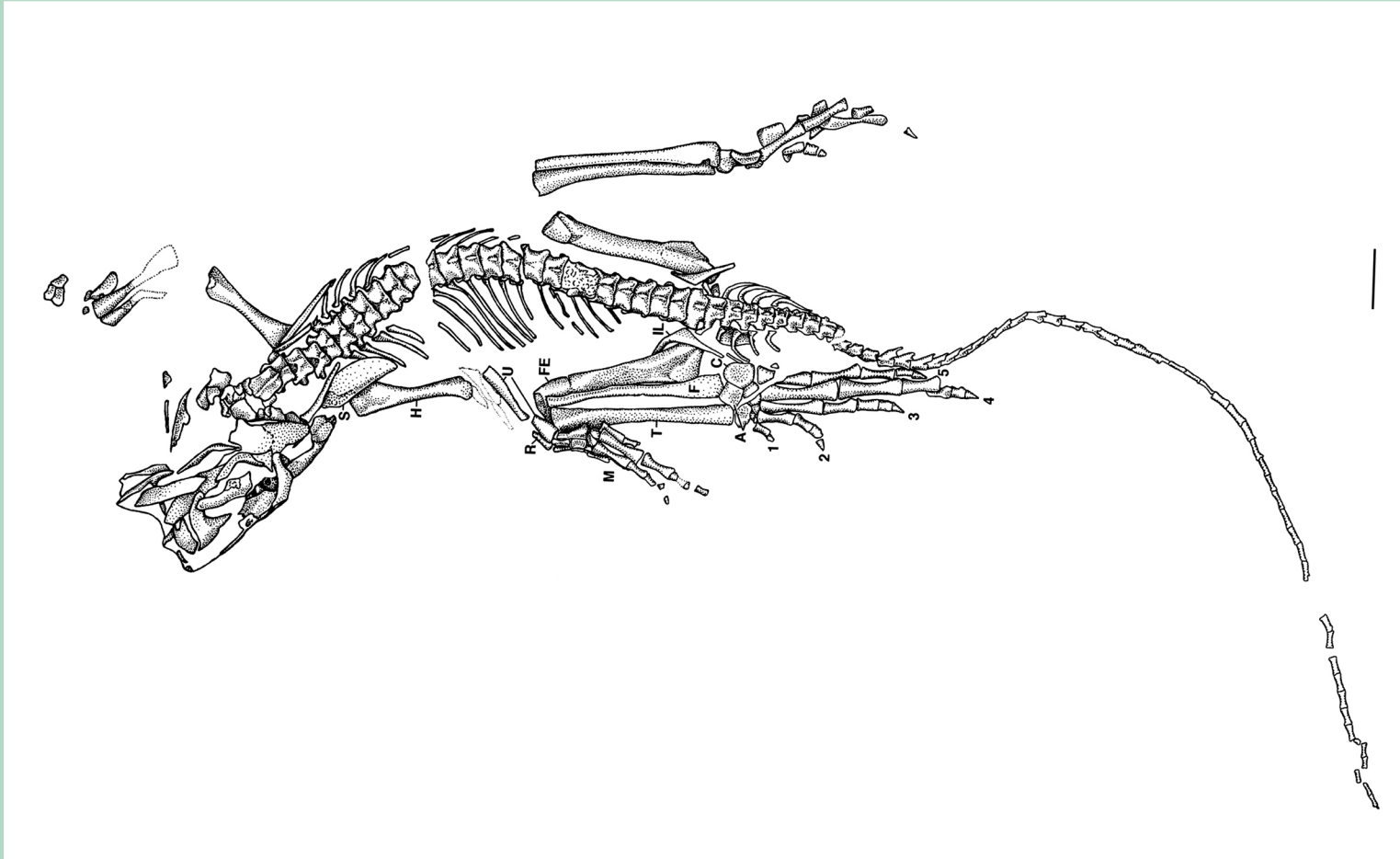


## MATERIAL

### 1. Introduction:

*Eudibamus* is an extinct genus of the *Bolosauridae* family that evolved during the Permian period approximately 280 million years ago. These mysterious vertebrates were classified as *Parareptilia* ("similar to reptilians") due to their reptiliomorphic anatomical characteristics, despite predating known reptilian species. The *Parareptilia* represent a unique evolutionary experiment, emerging before the divergence of vertebrate animals into amphibians, reptiles, and mammals.

The only known skeleton of *Eudibamus cursoris* was discovered at the renowned Bromacker Quarry in Thuringia (Central Germany), one of the world's prime fossil locations for early terrestrial vertebrates.



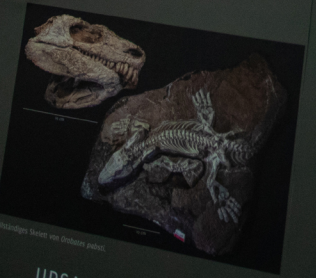
The Bromacker discoveries reveal a complex middle Permian ecosystem with diverse fauna and flora, including early terrestrial species such as *Orobates*, *Diadectes*, *Dimetrodon* and others. The site's silt-, sand- and clay stone sediments formed on a continental high plateau characterized by periodic water streams, ponds, and floodplains.

This Permian region, distant from marine environments, experienced an extreme continental climate with significant daily temperature fluctuations. It existed during the era of the supercontinent Pangaea, before its fragmentation into modern landmasses. Documented periodic temperatures below 0°C indicate that fauna and flora developed specialized anatomical adaptations to survive these climatic extremes. The vertebrate fauna of this period and region, termed "Ursaurier," while not direct ancestors of the later-evolving dinosaurs, represent the first documented truly terrestrial vertebrates in evolutionary history.



THÜRINGEN VOR  
290 MILLIONEN JAHREN

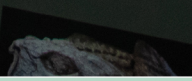
Das ist Thüringen vor ca. 290 Millionen Jahren. Die "Ursaurier" oder "Ursaurier" sind die ersten "echten" Landwirbeltiere, die sich an das Leben auf dem Festland angepasst haben. Sie sind die ersten Landwirbeltiere, die sich an das Leben auf dem Festland angepasst haben. Sie sind die ersten Landwirbeltiere, die sich an das Leben auf dem Festland angepasst haben.



URSAURIER-SKELETT  
*Diadectes absitus*

Ein nahezu vollständiges Skelett wurde auch von *Diadectes absitus* gefunden. Diese Art besaß ein differenziertes Gebiss mit verbreiterten Zähnen, die vermutlich zum Zerkleinern von faseriger Pflanzenmaterial dienten. Auf Grund der großen Schrittlänge des Tieres wird angenommen, dass es ausdauernd größere Entfernungen zurücklegen konnte.

URSAURIER-SKELETT  
*Orobates pabsti*





## RECONSTRUCTION

### 3. Reconstruction of Functional Morphology

#### 3.1. Locomotion

Already Berman et al. (2000) identified *Eudibamus cursoris* as the earliest known vertebrate capable of bipedal locomotion.

Now two new reconstruction models were developed: one depicting quadrupedal pose (the primary mode of locomotion) and another showing slightly clumsy bipedal running. The locomotion analysis incorporated motion studies of current species, particularly the strange bipedal running capabilities of *Basiliscus plumifrons* in order to understand the functional morphology of shifting locomotion.

The primary locomotion mode of *Eudibamus* was quadrupedal, with the animal traversing muddy pond margins and pioneer vegetation in the Bromacker environment. During quadrupedal locomotion, body mass was distributed across at least one front limb and one hind limb in contact with the ground. While climbing was possible, the diminutive claw morphology suggests this was not a primary behaviour.

When disturbed or excited and shifting into speed-walking, *Eudibamus* could shift its torso and head posteriorly, pivoting like a seesaw from a horizontal to a more upright position. The hindlimbs and feet were sufficiently long to support the redistributed body mass down to the body's centre. This posture assured bipedal locomotion, with forward momentum generated through controlled forward displacement of mass during each step, similar to extant bipedal organisms. *Eudibamus* was literally "falling" into its next step.

Unlike other Bromacker "Ursaurier" (*Orobates*, *Diadectes* and *Dimetrodon*), no definitive trackways have been associated with *Eudibamus*. The track-marks of *Tambachichnium* represent a likely match to *Eudibamus* or similar animals. Though its originator had to be at least double the size. This might be an indication that the holotype specimen of *Eudibamus cursoris* is a juvenile.



*Basiliscus plumifrons*

### 3.2. Metabolism and Ecology

The new reconstruction models provide new insights into the biological and functional morphology of *Eudibamus*: The emergence of bipedal locomotion 280 million years ago raises questions about its adaptive significance, whether for predator avoidance or prey acquisition. This leaves the question what further information can be concluded in regards to *Eudibamus*' morphology and biology.

The energetic efficiency principle suggests that organisms optimize energy expenditure relative to metabolic costs. This framework provides context for understanding the evolution of bipedalism in *Eudibamus*.

*Eudibamus* was previously described as herbivorous (D.S. Berman et al., 2000), similar to all other known *Bolosauridae*. This classification was based on their distinctive dentition, featuring pin-shaped frontal teeth and blunt-conical molars, seemingly adapted for plant consumption. However, *Eudibamus* is unique among *Bolosauridae* as the only species with preserved postcranial skeletal remains. Other specimens are limited to cranial fragments, and fossils of this group are extremely rare.

Examination of the *Eudibamus* skeleton reveals a notably small and slim thorax, providing insufficient space for the voluminous digestive tract and long intestines necessary for processing low-energy plant matter. During the lower Permian, vegetation consisted exclusively of gymnosperms such as ferns, club mosses, and conifers. Grasses, sugar-rich flowers, and energy-dense fruits were nonexistent. The Bromacker ecosystem's fossil record shows only sparse findings of small pioneer flora (*Callipteris*, *Wallchia*), raising questions about *Eudibamus*'s true dietary basis.

The agile animal had high energy requirements, while its tiny, slender body offered limited capacity for energy storage through body fat. Modern herbivorous ectotherms, such as Iguana iguana, supplement their leaf-based diet with sugar-rich tree fruits and readily consume insects or other energy-rich animal matter. These modern species inhabit warm regions with minimal temperature fluctuation, contrasting sharply with the dynamic Bromacker ecosystem's extreme continental climate featuring hot days, freezing nights, and regular monsoon events.

The food source for an animal with *Eudibamus*'s anatomy needed to be:

- Energy-rich and consistently available
- Small enough to swallow
- Relatively uninteresting to larger competitors

The Permian landscape at Bromacker was characterized by flood events, alluvial plains with residual pools, and sparse vegetation. Large leaf frond findings suggest nearby forests. Flowing water brought numerous insects, both dead and alive, to the drift lines. The decomposing plant material provided an ideal food source for the development and reproduction of diverse insects and arthropods, as extensively documented by countless fossil records of such kinds.

This abundant energy source likely served at least partially as a food source for *Eudibamus*. Their specialized dentition was well-suited for crushing the chitinous bodies of various beetles and cockroaches. This represents a unique ecological niche, similar to that occupied by modern wading birds of various sizes. Like these birds, *Eudibamus* was agile, capable of short sprints and possibly jumps to catch insects. This energy-rich diet would have enabled their high mobility, necessary for bipedal locomotion in obstacle-rich floodplains and undergrowth, and potentially supported enhanced intelligence beneficial for predator avoidance (possibly from *Dimetrodon*).



### 3.3 Skin Structure:

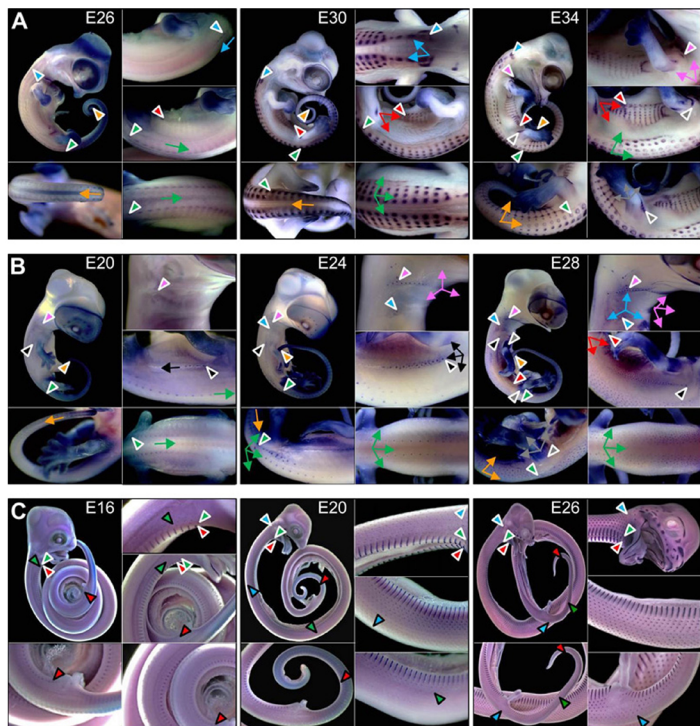
No fossilized skin remains of *Eudibamus cursoris* have been found. The species likely possessed specialized skin adapted to extreme periodic changes between wet and dry, cool and hot environments. The lateral skin was possibly soft and lobed, enabling amphibian-like skin respiration in moist conditions.

The exposed body surfaces of *Eudibamus* likely exhibited derived features alongside plesiomorphic traits. Early vertebrates, including fish and amphibians, possessed osseous scales. However, *Eudibamus* fossils show no evidence of such osteoderms. Keratinous scales likely evolved during the Permian period. Probably as early as the Permian period, keratinous scales evolved as protective integumentary structures, functioning analogously to ancestral osseous scales. The evolution of keratinous scales, a key feature of *Sauropsida*, remains poorly documented in the fossil record. This gap in fossil evidence presents challenges an update in phylogenetic systematics.

When classifying a skeleton as amphibian, reptile, or parareptilian, it's crucial to consider the evolutionary transitions between vertebrate classes. Modern reptilian characteristics, including keratin-scaled skin, didn't appear suddenly. The transition from amphibian to reptilian skin likely occurred gradually. It was likely a very slow process with several steps between an amphibian skin to one of a modern reptile.

The authors reconstruction models aim to visualize such a transitional species. To reconstruct early keratin scales, the author studied "placode" formations in turtle and lizard embryos (image left by N. Di-poi & M.C. Milinkovitch). These atavistic structures are rounded keratin shields embedded in the skin, which develop during ontogeny into typical scales. This inspired the author to design the homogeneous skin texture presented for *Eudibamus*. Claws, fingers, toes, shanks, and the head were likely the most exposed and stressed parts due to walking and running. Therefore, these areas were probably the most keratinized—similar to a real reptile, even though *Eudibamus* was not one.

Some elements in the reconstructions of the living *Eudibamus cursoris* stem from artistic interpretation. However, all aspects align with the fossil evidence, including the skeleton and environmental context, as reported in the current research. This represents an extraordinary and detailed glimpse into a long-extinct animal, considering the remarkable age of 280 million years for the Bromacker fossil discoveries.



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