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REPTILE TRACKWAY FROM THE LEE FORMATION (LOWER PENNSYLVANIAN) OF SOUTH-CENTRAL KENTUCKY

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ABSTRACT—An Early Pennsylvanian tetrapod trackway, referred to *Notalacerta missouriensis* Butts, was found in the Rockcastle Sandstone Member (Westphalian A, Upper Carboniferous) of the Lee Formation in McCreary County, Kentucky. Terrestrial characteristics of the trackway, such as digit length, claw marks, gait, and tail drag, suggest that it was made by a member of the primitive reptile family Protorothyrididae. If identified correctly, this is the oldest known reptile trackway in North America. The animal that made the trackway was approximately 0.4 m in length. The pes tracks are slightly larger and set slightly wider than the manus tracks; digits are elongated and slender, and the fourth digit of the pes is the longest. Whereas the slender, long toes indicate a terrestrial form, the gait was more advanced than the sprawling gait typical of the most primitive tetrapods.

INTRODUCTION

A TETRAPOD trackway discovered by Mr. Roy Hines in a sandstone quarry at Day Ridge, McCreary County, Kentucky (Figure 1), was brought to the attention of the late Richard Q. Lewis, Sr., of the U.S. Geological Survey in 1972 (Lewis, 1973). Lewis recognized the scientific importance of this find and, upon retirement, encouraged the late J. Hiram Smith of the U.S. Geological Survey (later of the Kentucky Geological Survey) and several vertebrate paleontologists to undertake a definitive analysis of the trackway. Extenuating circumstances delayed additional work on the discovery until this report was prepared by the two senior authors.

The now-abandoned Day Ridge Quarry is on Kentucky Highway 927, approximately 4.6 km west of U.S. Highway 27 near Parkers Lake, McCreary County, Kentucky (Nevelsville geologic quadrangle map [Smith, 1976], Carter coordinate location 22-E-60, 2,800' FSL, 3,750' FEL or longitude 84°31'46" west, latitude 36°50'28" north) (Figure 1).

The trackway is preserved as casts on the underside of a light yellowish-gray, fine-grained, quartzose sandstone bed that is less than 1.5 m below the top of the Rockcastle Sandstone Member of the Lee Formation (Lower Pennsylvanian) (Figure 2). The trackway bed is 0.13 m thick, and is one of a set of thin-bedded (10–260 mm) sandstones interbedded with thin layers of dark-gray shale (<20 mm). Only 1.8 m of the thin-bedded sandstone and shale is exposed in the quarry. The even bedding and shale parting made it possible for this stone to be extracted in large slabs ("freestone") suitable for construction. The primary sedimentary features exhibited on the undersides of the slabs are abundant nonmarine? traces, casts of mudcracks from the underlying thin shales, and the tetrapod trackway. Some slabs exhibit asymmetric ripples.

The Rockcastle Sandstone (Figure 2) is of Early Pennsylvanian age, equivalent to part of the Morrowan Series of the North American Midcontinent and the upper part of the New River Formation of West Virginia. According to Smith and Butterworth (1967), the Westphalian A–B boundary is marked by the disappearance of the spore *Schulzospora rara* and the appearance of the spore *Endosporites globiformis*. R. Kosanke (personal commun.) examined the spores from the Barren Fork coal (maceral number 341), just a few meters above the Rockcastle

Sandstone (Figure 2), and reported *Schulzospora rara* from this coal, but no *Endosporites*, indicating that the trackway is Westphalian A in age by the system of Smith and Butterworth.

DESCRIPTION

The trackway (Figures 3, 4) is 0.745 m long and consists of manus (forefoot) and pes (hindfoot) sets, as well as a tail-drag impression. For the first 0.26 m the trackway is straight.

Measurements of pace, stride, trackway width, gleno-acetabular distance, pace angulation, and manus and pes size are given in Table 1. A reconstructed trackway demonstrates how these measurements were made (Figure 5). No single footprint was complete; therefore, a composite was made from all the footprints. Size, shape, and interdigital angles for the manus and pes are shown in Figure 6.1.

The manus and pes have long, flexible digits with distinct articular nodes, and small claws. The manus is pentadactyl with a cordiform palm (Figure 6.1). The pes imprint is immediately posterior to the manus and overlaps slightly in some places the palmar area. The pes is pentadactyl. The fourth digit appears to be the longest, whereas the first digit is the shortest. We are uncertain regarding the length of the fifth digit of the pes. Although the length of the fifth digit appears to be fairly short in most imprints, faint impressions in some of the imprints support a fairly long digit as shown in the reconstruction (Figure 6.1). Either interpretation (short or long fifth digit) is reasonable. The posterior area of the pes is not well preserved in any of the footprints.

The tail drag is well preserved in the first two-thirds of the trackway and poorly preserved in the last third. No undulations are apparent in the tail drag.

Remarks.—The gleno-acetabular lengths, measured from the midpoint of the left and right manus to the midpoint of the corresponding left and right pes, are used to deduce the trunk length (distance from the pelvic girdle to the shoulder) (Table 1). Unfortunately, it is difficult to determine which pes set corresponds to a given manus set. Two likely possibilities exist: there were no unoccupied footprints between the front and hind feet (type 1), or there was one set of unoccupied footprints between the front and hind feet (type 2). Although the pes overlaps the manus prints in some places, the toetips of the pes could

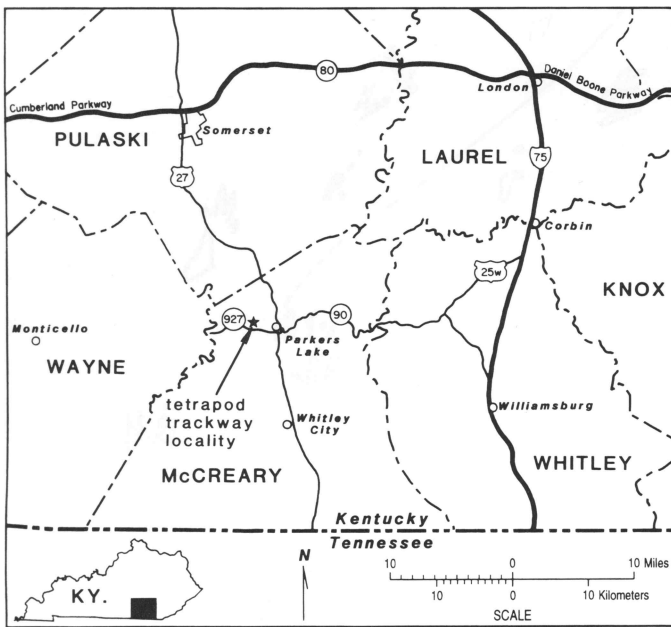


FIGURE 1—Location of Days Quarry site, south-central Kentucky.

have implanted as the manus rolled upward at the end of its stroke. A type 1 animal would have had a short body with proportionately large feet. A type 2 animal would have had a longer body.

A moderately high pace angulation (Table 1) for the manus suggests that the forelimbs were positioned under the body during locomotion, as opposed to being spread out in a sprawling gait. The moderately low pace angulation for the hindlimbs suggests a slightly sprawling gait. The different pace angulations are consistent with the different trackway widths (Table 1) of the fore and hindlimbs. This gait is a marked advance over a purely sprawling gait. The straight taildrag indicates that the tail was a relatively inert appendage and not a propulsive agent in walking. Slender toes with long fourth and fifth digits, possible claw marks, proportionately large feet, advanced gait, and straight tail drag indicate a fully terrestrial animal.

Occurrence.—Pennsylvanian System, Kansas, Kentucky, and Missouri.

TABLE 1—Measurements of *Notalacerta missouriensis* Butts (1891) from the Days Quarry site.

| | Average | Number of Measurements | Standard deviation |
|---------------------------|---------|------------------------|--------------------|
| Pace | 47 mm | 22 | 9 mm |
| Stride | 95 mm | 21 | 6 mm |
| Pace angulation | | | |
| Manus | 92° | 10 | 9° |
| Pes | 72° | 10 | 6° |
| Trackway width | | | |
| Manus–pes (standard) | 54 mm | 11 | 6 mm |
| Manus–manus | 45 mm | 12 | 6 mm |
| Pes–pes | 63 mm | 11 | 6 mm |
| Gleno-acetabular distance | | | |
| Type 1 | 70 mm | 11 | 6 mm |
| Type 2 | 165 mm | 9 | 6 mm |
| Manus width | 22 mm | composite | — |
| Manus length | 30 mm | composite | — |
| Pes width | 37 mm | composite | — |
| Pes length | 37 mm | composite | — |

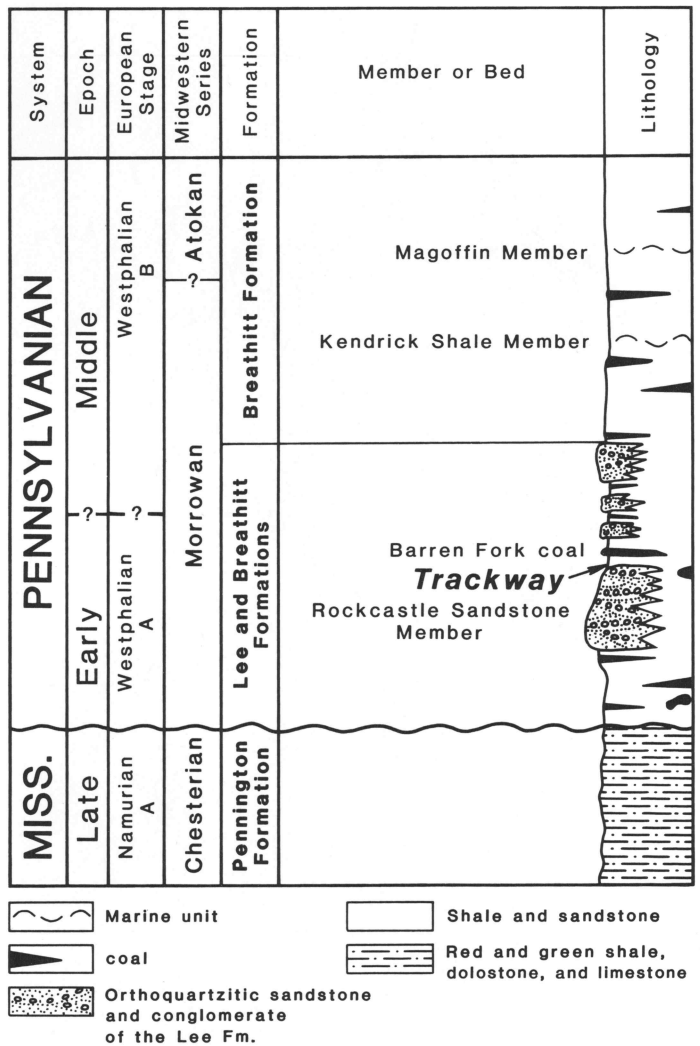


FIGURE 2—Generalized columnar section of Carboniferous rocks in south-central and southeastern Kentucky. No vertical scale implied. The marine Kendrick and Magoffin Members are key stratigraphic units extensively mapped in Kentucky.

Material.—The trackway slab has been donated by Mr. Roy Hines to the Hudnall Geology Museum of the Department of Geological Sciences, Bowman Hall, University of Kentucky, Lexington, Kentucky.

Two latex molds of the slabs were prepared by Lewis and Smith. One is deposited in the Paleontological Collections of the Kentucky Geological Survey as specimen number KGS 1381 (latex-type).

DISCUSSION

Although reconstructions of this trackway (Figure 6.1) suggest a fairly long but faintly impressed fifth digit on the pes, this trackway differs in no significant way from *Notalacerta missouriensis* Butts (1891) from the Missourian of Kansas City, Missouri (Figure 6.2). Particularly close comparisons can be made with the topotypic specimens USNM 7321 (U.S. National Museum of Natural History), making allowance for its broken right pes digit IV and MCZ 205 (Museum of Comparative Zoology, Harvard), which shows the metatarso-phalangeal articulations. Butt's type specimens are unlocated but contemporary

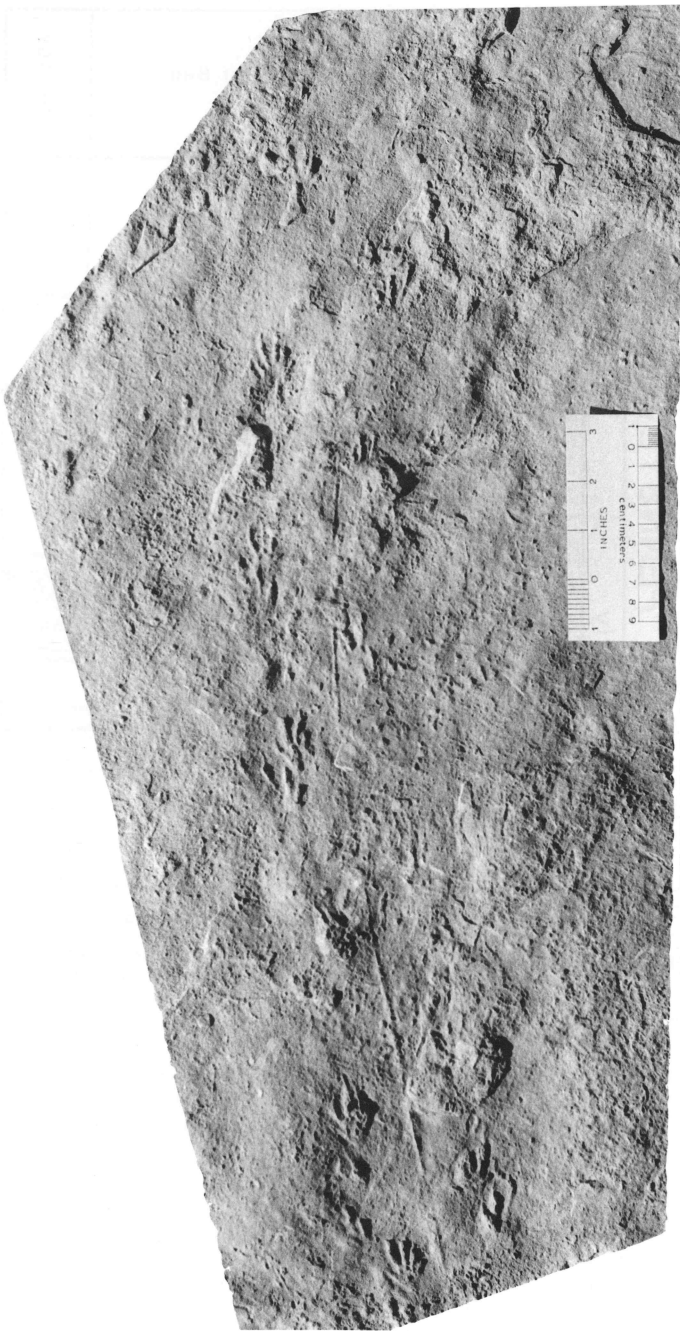


FIGURE 3—Photograph of the trackway cast on the underside of the “freestone” block.

photographs of them that were taken by the collector, Sidney J. Hare, are preserved in the National Museum of Natural History (Baird, 1982). Photocopies of these pictures have been used for comparison.

Excellent trackways that are essentially indistinguishable from *Notalacerta missouriensis* also occur in the Rock Lake Member of the Stanton Formation at the classic site of Garnett, Kansas. This occurrence is also Missourian in age but somewhat younger than the type locality. Coming as it does from strata of Westphalian A age, the Kentucky trackway is substantially older than these occurrences.

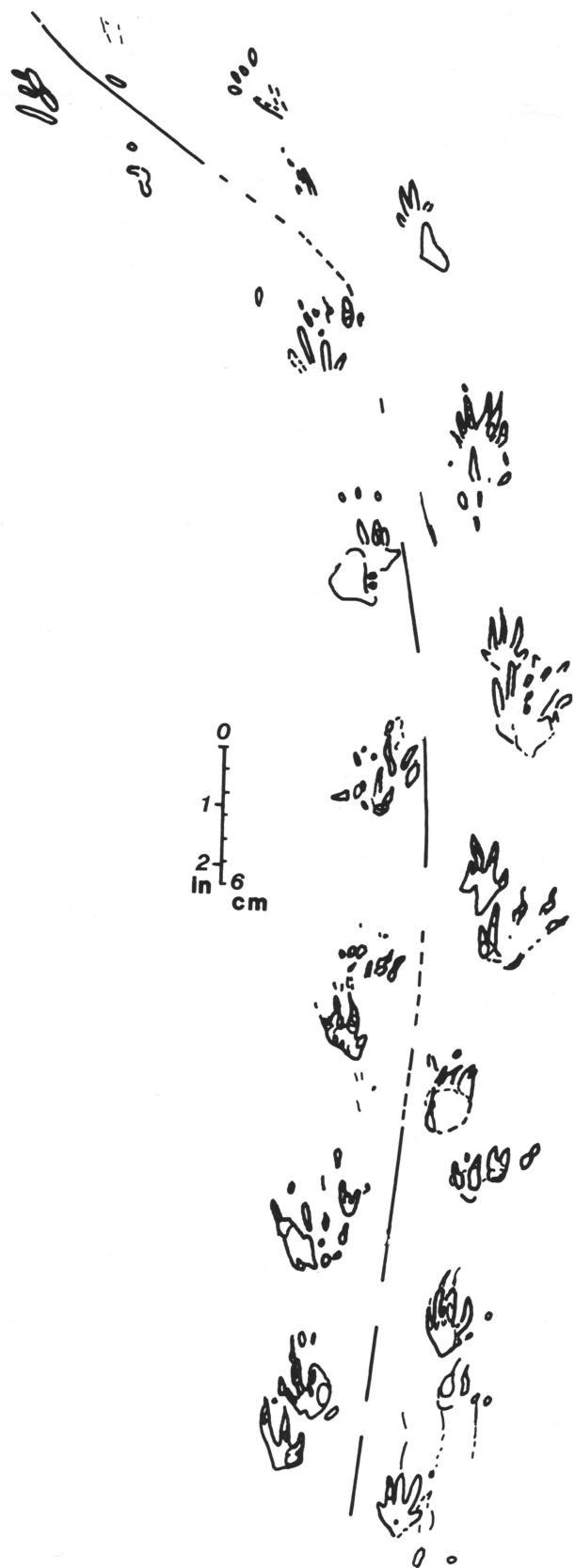


FIGURE 4—Tracing of latex mold of the sandstone cast.

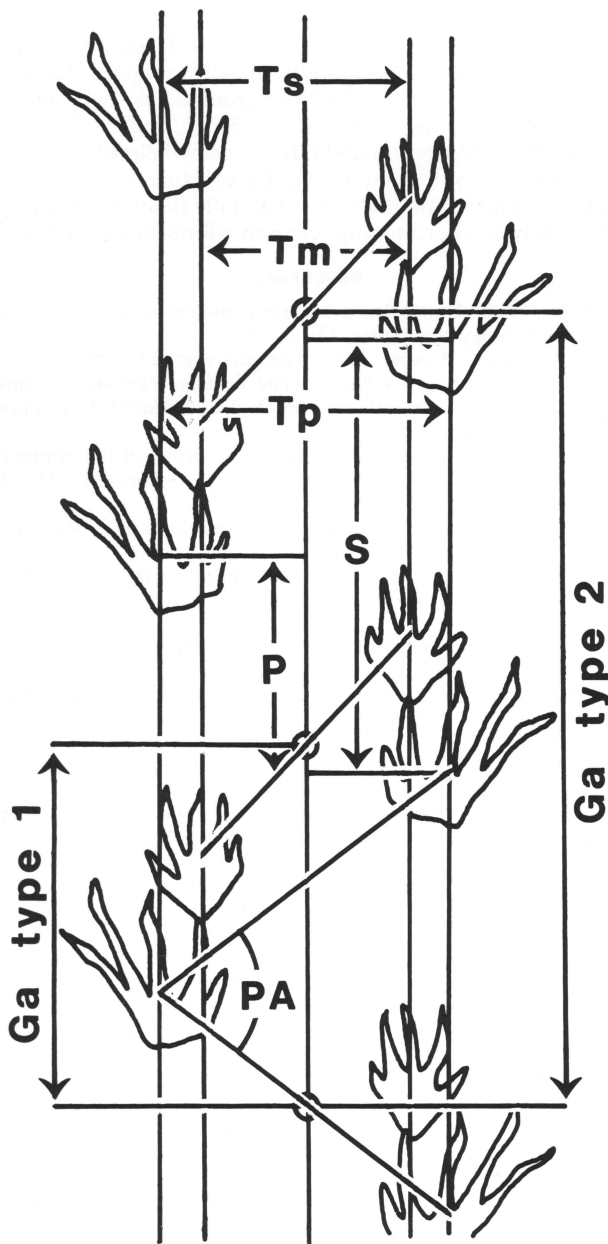


FIGURE 5—Explanation for measurements in Table 1. P, pace; S, stride; PA, pace angulation; Ts, standard trackway width; Tm, trackway width of manus set; Tp, trackway width of pes set; Ga type 1, gleno-acetabular distance of type 1 gait; Ga type 2, gleno-acetabular distance of type 2 gait.

In comparing Paleozoic trackways with taxa based on skeletal material we are hampered by the fact that, in most of the latter, the feet are unknown. Whole groups of animals must therefore be omitted from comparison for lack of evidence. Even in the few taxa for which foot material is known it is seldom complete enough to permit a factual reconstruction of both manus and pes. Our attempts at correlation will necessarily be tentative at best.

Because the foot structure of *Notalacerta* is obviously reptiliomorph, our attention must focus on the early reptiles and their amphibian allies within the order Anthracosauria. Although the taxonomy and nomenclature of the latter group are currently in

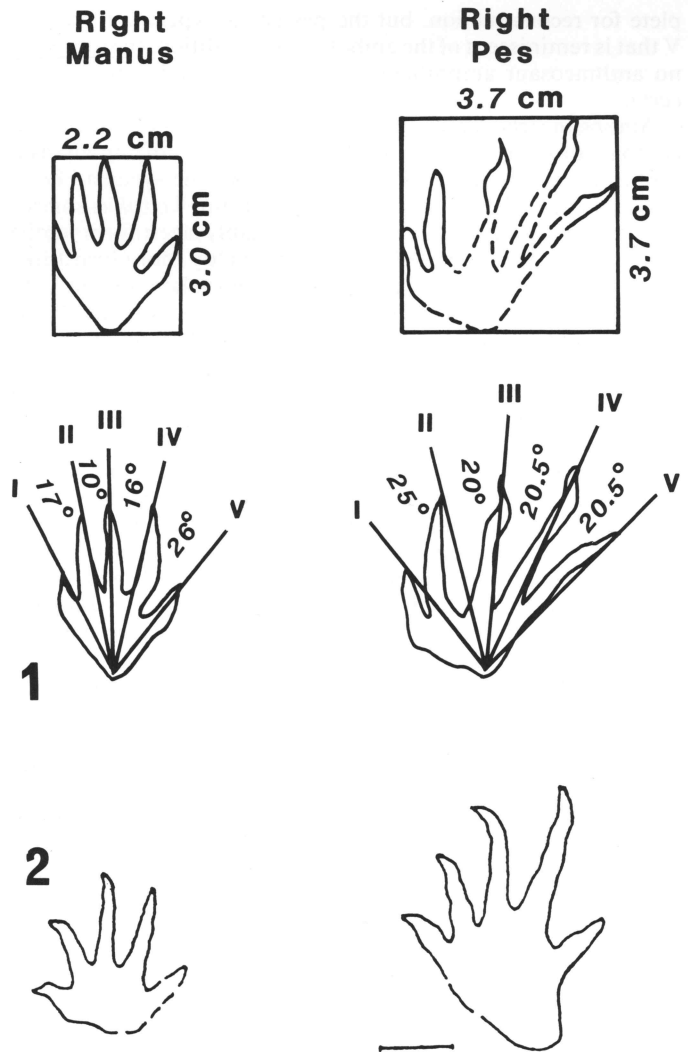


FIGURE 6—1, reconstruction of manus and pes of Kentucky specimen showing shape, size, and interdigital angles. 2, *Notalacerta missouriensis* Butts (composite from topotypes and photographs of types). Just above the Cement City Limestone of the Chanute Formation, Upper Pennsylvanian (Missourian); Kansas City, Missouri. Scale bar = 1 cm.

dispute, it is generally agreed to consist of three components: the seymouriamorphs *sensu stricto*, a group of derived forms from the Permo-Carboniferous; the embolomeres, a long-lived group of long-bodied forms with tails specialized for aquatic propulsion; and the *gephyrostegids*, which are known only from the Upper Carboniferous.

So far as known, the seymouriamorphs are excluded from comparison by their broad feet with relatively stubby toes. Body proportions of embolomeres appear to be incompatible with a trackmaker of the *Notalacerta* type; the pes structure is similar except for a hypertrophied digit V but the manus digits are relatively short, as befits a primarily aquatic animal that used its tail and hind paddles in swimming. Among *gephyrostegids*, the feet are best known in *Gephyrostegus* (Carroll, 1970) and *Brukererpeton* (Boy and Bandel, 1973). In *Gephyrostegus* (with which *Eusauroploera* is probably synonymous), the feet are distinctly reptilian in form but they do not have such long, lacertoid toes as *Notalacerta*. The manus of *Brukererpeton* is too incom-

plete for reconstruction, but the pes has a hypertrophied digit V that is reminiscent of the embolomere condition. In summary, no anthracosaur amphibian is closely comparable to *Notalacerta*.

Among the true reptiles known from the Carboniferous, useful comparisons can be made only with members of the anapsid captorhinomorph family Protorothyrididae, the synapsid Pelycosauria, and the late-appearing diapsid genus *Petrolacosaurus*. The latter genus (Reisz, 1981) is a remarkably lacertiform reptile with narrow, long-toed feet that are distinctly more lizard-like than those of *Notalacerta* and appear to correlate, rather, with the late Pennsylvanian and early Permian footprint genus *Dromopus* (Patterson, 1971). Romer and Price's (1940) review of the Pelycosauria shows only two genera, *Varanops* and *Varanosaurus*, that have markedly lacertoid feet. Neither of these genera has such attenuated toes as *Notalacerta*; both are early Permian or possibly latest Carboniferous in age.

The closest relative for *Notalacerta* is to be found among Pennsylvanian representatives of the Protorothyrididae ("Romeriidae" of earlier literature). In two genera of late Westphalian D age, *Paleothyris* from Florence, Nova Scotia (Carroll, 1969), and *Anthracodromeus* from Linton, Ohio (Carroll and Baird, 1972), the feet have been reconstructed from nearly complete material. The close correspondence in foot structure between these genera and *Notalacerta* is too obvious to require detailed argument. In addition, both genera are reptiles with moderately short trunks and conspicuously large feet. The body proportions of *Anthracodromeus* are such that, in normal walking pose, the toe-tips of the pes could implant below the carpus of the ipsilateral manus as the latter rolled upward at the end of the propulsive stroke (precisely the situation seen in some manus-pes sets of the type 1 *Notalacerta*).

While correlation of the ichnogenus *Notalacerta* with any particular genus of protorothyridid would be unjustifiable, we are confident that the reptiles responsible for it were members of that family. The earliest known representative of the group, *Hylonomus* from the Westphalian B of Nova Scotia (Carroll, 1964), is younger by only a substage than the Kentucky trackway. There is thus no chronological discrepancy between *Notalacerta* and the Protorothyrididae.

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