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Enigmatic dinosaur footprints from the Lower Jurassic of Poland

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Three unusual dinosaur ichnites are reported from the Hettangian strata of the Holy Cross Mountains, Central Poland. The tracks are compared with similar forms from the Upper Triassic and Lower Jurassic of North America. The Polish footprints resemble *Stenonyx* Hitchcock (1865), a very small print presumably left by a diminutive or a baby theropod, and *Atreipus* Olsen and Baird (1986), a footprint suspected to be of ornithischian origin, basically known from Late Triassic deposits.

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INTRODUCTION

Sołtyków and Gliniany Las were the first discovered, and thus far the richest and the best known dinosaur tracksites in the Lower Jurassic of Poland (e.g. Gierliński, 1991, 1995, 1996, 1999; Gierliński and Sawicki, 1998; Gierliński and Pieńkowski, 1999; Gierliński *et al*., 2001). However, continued investigation into material collected during the last two decades continues to reveal new informations. Here we describe three specimens: Muz. PIG 1560.II.23, 40 and 62. All are preserved as natural casts. The footprint of a very small tridactyl biped (Muz. PIG 1560.II.23, Fig. 2A) and the track of a quadrupedal trackmaker (Muz. PIG 1560.II.40, Fig. 3A) came from late Hettangian barrier-lagoonal sediments belonging to the Przysucha Ore-Bearing Formation, exposed in the Gliniany Las quarry. The footprint of a very small biped occurs on slab Muz. PIG 1560.II.23, where the sitting trace of *Anomoepus pienkovskii* Gierliński (1991), is also preserved.

The footprint Muz. PIG 1560.II.62 (Fig. 1A) is similar to the small one from Gliniany Las, and it was found in the early Hettangian alluvial plain sediments of the lower Zagaje Formation, in Sołtyków.

The tracks described herein are interpreted only tentatively, despite their good preservation, because of their doubtful affinities.

DESCRIPTION AND DISCUSSION

The Sołtyków specimen Muz. PIG 1560.II.62 (Fig. 1A) is a 54 mm long tridactyl footprint with a total digit divarication of 30°. The digit length ratios (according to the method of Olsen *et al*., 1998) are: III/II = 1.16, III/IV = 0.77. Interestingly, these ratios are the same as those of a ten millimetre smaller ichnite CU-MWC 183.2 (Fig. 1B) from the Lower Jurassic of Utah, a footprint reported by Lockley (1986) and Lockley and Hunt (1995).

The Gliniany Las specimen Muz. PIG 1560.II.23 (Fig. 2A) was left by a very small tridactyl biped and is 56 mm long. Its total digit divarication equals 44°, while digit length ratios are: III/II = 1.30, III/IV = 0.95. These parameters resemble *Stenonyx lateralis* Hitchcock (1865), a print almost twice smaller (30 mm long) from the Lower Jurassic of Massachusetts (specimen AC 47/40, Fig. 2B). The total digit divarication of AC 47/40 is 42°, while digit length ratios are: III/II = 1.36, III/IV = 0.96.

Weems (1992) has considered *Stenonyx lateralis* as the baby track of the *Kayentapus* Welles (1971) trackmaker. However, James O. Farlow (written comm., 2002) has noted that the digits in the Polish specimen are much more spread out at their proximal ends than in *Stenonyx lateralis*, which might suggest a difference in the architecture of the distal end of the metatarsus of the two trackmakers. Moreover, the very rich Gliniany Las assemblage lacks *Kayentapus*. Thus, the Polish

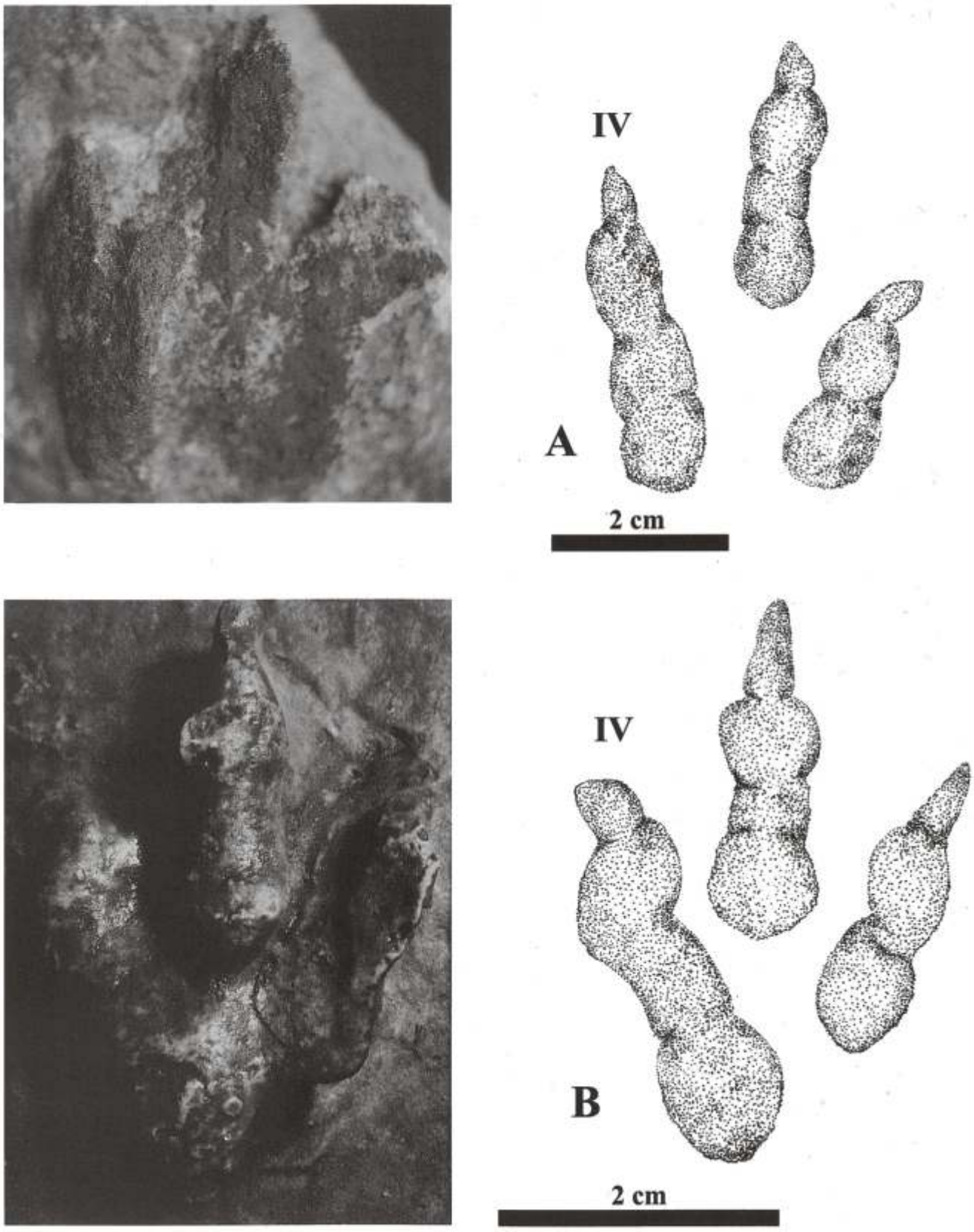

Fig. 1. **A** — cf. *Stenonyx* sp. (Muz. PIG 1560.II.62) from the Zagaje Formation of Sołtyków, Poland in comparison with **B** — cf. *Stenonyx* sp. (CU-MWC 183.2) from the Navajo Formation of Sand Wash site, Utah

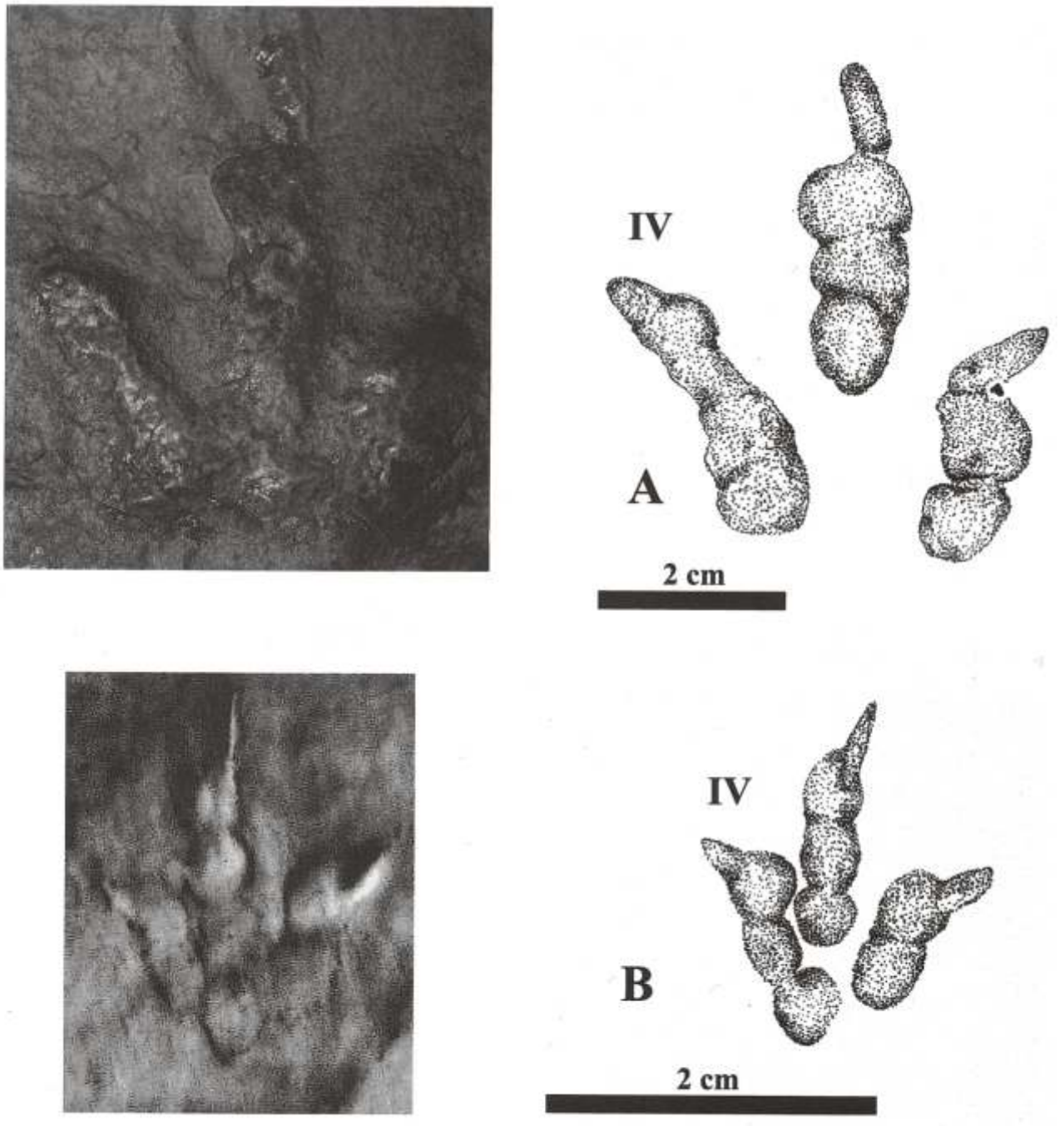

Fig. 2. **A** — cf. *Stenonyx* sp. (Muz. PIG 1560.II.23) from the Przysucha Ore-Bearing Formation of Gliniany Las, Poland in comparison with **B** — the holotype of *Stenonyx lateralis* Hitchcock (1865) (AC 47/40), from the Portland Formation of Turners Falls, Massachusetts

specimen Muz PIG 1560.II.23 seems to have been made by some diminutive theropod or a juvenile of some other form, different from the *Kayentapus* tracmakers. According to the data given by Olsen *et al.* (1998), the digit length ratios of both the discussed ichnites are indeed closer to those of large theropods such as *Liliensternus* Welles (1984) (III/II = 1.32, III/IV = 0.82) and *Dilophosaurus* Welles (1970) (III/II = 1.38, III/IV = 0.86) rather than to the small early theropods.

In our opinion, the footprints from Sołtyków (Muz. PIG 1560.II.62) and Utah (CU-MWC 183.2) correspond to the *Stenonyx* pattern and should be referred to this ichnogenus, rather than to other forms. Other diminutive theropod tracks, *Wildeichnus navesi* Casamiquela (1964) from the Middle Jurassic of Argentina, differ from the Polish and North American specimens in having a higher projected middle toe, as well as thinner and more widely divaricated digits.

Specimen Muz. PIG 1560.II.40 (Fig. 3A) is the next problematic ichnite from the Lower Jurassic of Poland. The track comprises a tridactyl pes (11.8 cm long, 7.7 cm wide) and a tridactyl manus (4 cm long, 4.4 cm wide). The pedal digit length ratios are: III/II = 1.23, III/IV = 0.79. The ratio of the third digit projected beyond the lateral digits to the footprint

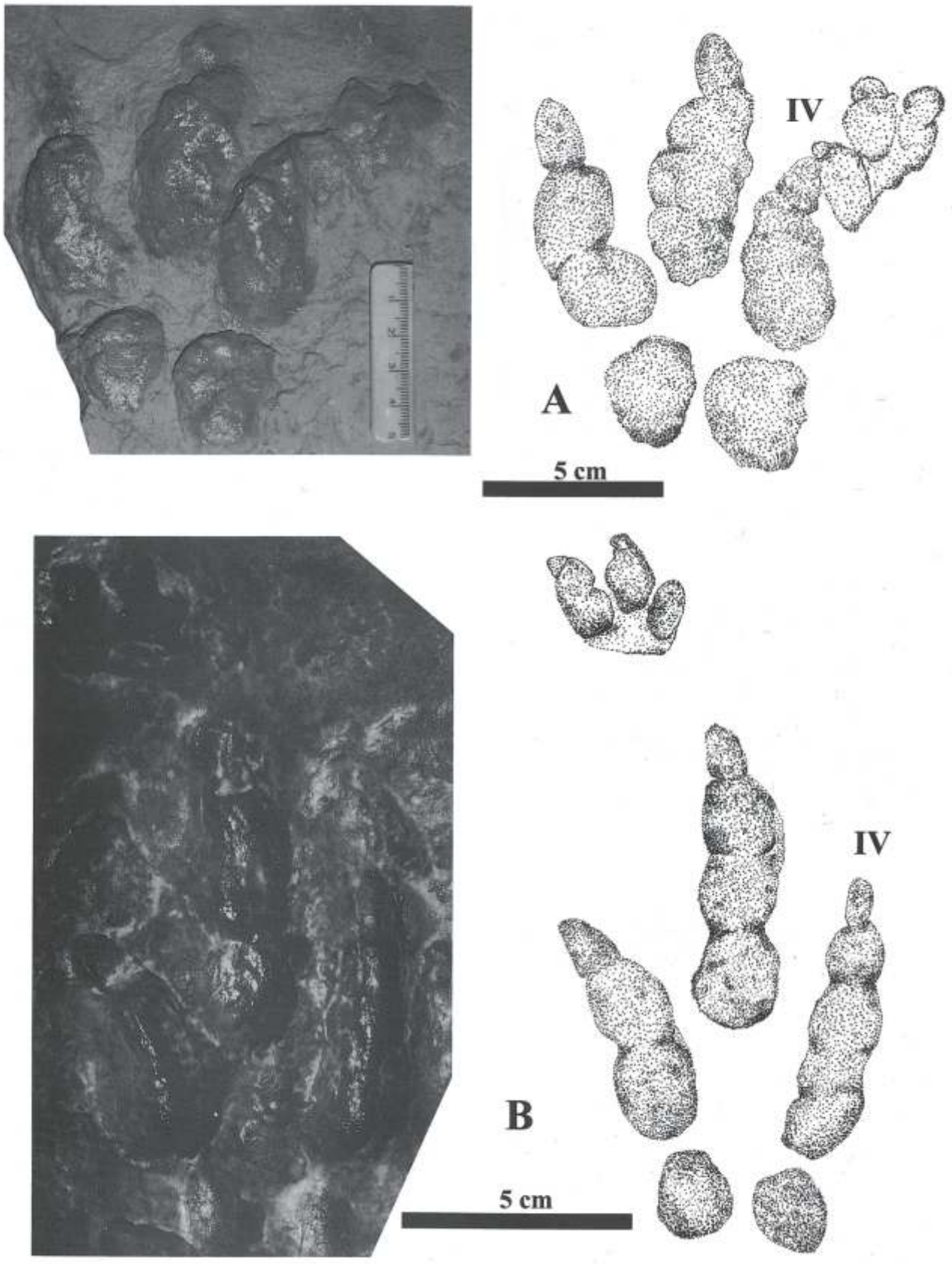

Fig. 3. **A** — cf. *Atreipus* sp. (Muz. PIG 1560.II.40) from the Przysucha Ore-Bearing Formation of Gliniany Las, Poland in comparison with **B** — *Atreipus* sp. (GNCRA specimen) from the Chinle Formation of Four Mile Canyon, Utah

width equals 0.33. The manual morphology and the pedal digit length ratios well fit the specimen from the Chinle Formation of Utah (Fig. 3B) described by Lockley *et al.* (1998) as *Atreipus* Olsen and Baird (1986). However, the ratio of the third digit projection to the footprint width in the American specimen is markedly different (0.57), the digits are thinner, the footprint is more slender and the manus is located anteromedially to the pes, farther from the pedal print. Moreover, "classic" *Atreipus* tracks are known from the Upper Triassic.

The only hitherto known *Atreipus*-like tracks in post-Norian strata have been described as *Delatorrichnus* Casamiquela, 1964 from the Middle Jurassic of Argentina, and possibly also occurring in the Lower Jurassic of Zimbabwe (Lingham-Soliar and Broderick, 2000).

The "classic" Late Triassic tracks of *Atreipus* show a combination of small theropod-like (*Grallator*-like) pes with the primitive archosaurian (chirotheriid) manus which is much smaller then the pes. Olsen and Baird (1986) have argued that such a combination might have been made by a basal ornithischian trackmaker. Contrary to the opinion of Olsen and Baird (1986), and Gierliński (1994), other authors, Thulborn (1990) and Weems (1992) preferred a theropod origin for *Atreipus* ichnites. If those authors are right and *Atreipus* was made by a quadrupedal theropod, then an interesting paradox appears. If the atreipodid manual imprint was produced by a theropod, than the Polish *Atreipus*-like track Muz. PIG 1560.II.40 shows a combination of an ornithischian-like pes with a theropod manus.

Despite the similarities of the pedal digit length ratios between Muz. PIG 1560.II.40 (Fig. 3A) and *Atreipus* sp. from the Upper Triassic of Utah (Fig. 3B), the Polish specimen is clearly distinguished by a more ornithischian-like pes than any *Atreipus* footprint. Specimen Muz. PIG 1560.II.40 has even been previously misinterpreted as an *Anomoepus* Hitchcock (1848) track (Gierliński, 1995). Its digit length ratios resemble those of *Heterodontosaurus* Crompton and Charig (1962) (III/II = 1.32, III/IV = 0.73; according to Olsen *et al.*, 1998). This observation concerns also the American specimen from the Chinle Formation with digit length ratios: III/II = 1.31, III/IV = 0.70. However, heterodontosaurid remains are unknown in the Upper Triassic and the *Atreipus* manual morphology does not closely match the *Heterodontosaurus* manual pattern. The *Heterodontosaurus* manus is very large in comparison to the pes, much too large to fit the manus-pes area ratio of *Atreipus*, which is around 1:10. Naturally, if the quadrupedal stance of *Heterodontosaurus* suggested by Paul (1987) is correct, then the animal might have possessed functionally subdigitigrade or even unguligrade forelimbs while walking. In such circumstances, manual impressions might be as small as we can see in *Atreipus*, but then the reduced heterodontosaurid manual digit IV and V would not touch the ground. Thus, a hypothetical heterodontosaurid manual impression might never be tetradactyl as it appears in *Atreipus acadianus* Olsen and Baird (1986), and the impressions of manual digits should increase in length in the sequence I, II, III not I, IV, II, III as it is shown by *Atreipus* tracks.

However, we cannot reject the possibility that a heterodontosaurid might be responsible for the post-Norian *Atreipus*-like tracks. Their manual prints are always tridactyl, we do not know their exact digit numeration, and those manual prints are slightly larger in comparison to the pes than in the "classic" Triassic *Atreipus*. In specimen Muz. PIG 1560.II.40, the manus-pes area ratio equals 1:7.

Abbreviations of cited repositories: AC — Pratt Museum of Natural History, Amherst College, Amherst, Massachusetts, USA; CU-MWC — University of Colorado/Museum of Western Colorado Joint Collection, Denver, Colorado, USA; GCNRA — Glen Canyon National Recreation Area, Utah, USA; Muz. PIG — Geological Museum of the Polish Geological Institute, Warsaw, Poland.

REFERENCES

CASAMIQUELA R. M. (1964) — Estudios Icnológicos. Problemas y métodos de la Icnologica con aplicación al. Estudio de pisadas mesozoicas (Reptilia, Mammalia) de la Patagonia. Colegio Industrial Pio IX. Buenos Aires.

CROMPTON A. W. and CHARIG A. J. (1962) — A new ornithischian from the Upper Triassic of South Africa. Nature, **196**: 1074–1077.

GIERLIŃSKI G. (1991) — New dinosaur ichnotaxa from the Early Jurassic of the Holy Cross Mountains, Poland. Palaeogeogr., Palaeoclimat., Palaeoecol., **85**: 137–148.

GIERLIŃSKI G. (1994) — Early Jurassic theropod tracks with the metatarsal impressions. Prz. Geol., **42** (4): 280–284.

GIERLIŃSKI G. (1995) — Śladami polskich dinozaurów: 1–88. Polska Oficyna Wydawnicza BGW.

GIERLIŃSKI G. (1996) — Avialian theropod tracks from the Early Jurassic strata of Poland. Zubia, **14**: 79–87.

GIERLIŃSKI G. (1999) — Tracks of large thyreophoran dinosaur from the Early Jurassic of Poland. Acta Palaeont. Pol., **44** (2): 231–234.

GIERLIŃSKI G. and PIEŃKOWSKI G. 1999 — Dinosaur track assemblages from the Hettangian of Poland**.** Geol. Quart., **43** (3): 329–346.

GIERLIŃSKI G. and SAWICKI G. (1998) — New sauropod tracks from the Lower Jurassic of Poland**.** Geol. Quart., **42** (4): 477–480.

GIERLIŃSKI G., NIEDŹWIEDZKI G. and PIEŃKOWSKI G. (2001) — Gigantic footprint of the theropod dinosaur in the Early Jurassic of Poland. Acta Palaeont. Pol., **46** (3): 441–446.

HITCHCOCK E. (1848) — An attempt to discriminate and describe the animals that made the fossil footmarks of the United States, and especially of New England. Mem. Amer. Acad. Arts Sc., **2** (3): 129–256.

HITCHCOCK E. (1865) — Supplement to the ichnology of New England: 1–96. Wright and Potter. Boston.

LINGHAM-SOLIAR T. and BRODERICK T. (2000) — An enigmatic early Mesozoic dinosaur trackway from Zimbabwe. Ichnos, **7**: 135–148.

LOCKLEY M. G. (1986) — A guide to dinosaur tracksites of the Colorado Plateau and American Southwest. University of Colorado at Denver. Geology Department Magazine, **1**: 1–56.

LOCKLEY M. G. and HUNT A. P. (1995) — Dinosaur tracks and other fossil footprints of the western United States. Columbia University Press. New York.

LOCKLEY M. G., HUNT A. P., MEYER C. A., RAINFORTH E. C. and SCHULTZ R. J. (1998) — A survey of fossil footprint sites at Glen Canyon National Recreation Area (Western USA): a case study in documentation of trace fossil resources at a National Reserve. Ichnos, **5**: 177–211.

OLSEN P. E. and BAIRD D. (1986) — The ichnogenus Atreipus and its significance for Triassic biostratigraphy. In: The Beginning of the Age of Dinosaurs: Faunal Change Across the Triassic-Jurassic Boundary (ed. K. Padian): 61–87. Cambridge University Press. Cambridge.

OLSEN P. E., SMITH J. B. and McDONALD N. G. (l998) — The material of the species of the classic theropod footprint genera *Eubrontes*, *Anchisauripus* and *Grallator* (Early Jurassic, Hartford and Deerfield basins, Connecticut and Massachusetts, U.S.A.). J. Vertebrate Paleont., **18**: 586–601.

PAUL G. S. (1987) — The science and art of restoring the life appearance of dinosaurs and their relatives. In: Dinosaurs Past and Present **II** (eds. S. J. Czerkas and E. C. Olson): 5–49. Natural History Museum. Los Angeles County.

THULBORN R. A. (1990) — Dinosaur tracks. Chapman and Hall. London.

WEEMS R. E. (1992) — A re-evaluation of the taxonomy of Newark Supergroup saurischian dinosaur tracks, using extensive statistical data from a recently exposed tracksite near Culpeper, Virginia. In: Proc. 26th Forum on the Geology of Industrial Minerals (ed. P. C. Sweet). Virginia Division of Mineral Resources Pub., **119**: 113–127. Charlottesville.

WELLES S. P. (1970) — *Dilophosaurus* (Reptilia, Saurischia), a new name for a dinosaur. J. Paleont., **44**: 989.

WELLES S. P. (1971) — Dinosaur footprints from the Kayenta Formation of northern Arizona. Plateau, **44** (1): 27–38.

WELLES S. P. (1984) — *Dilophosaurus wetherilli* (Dinosauria, Theropoda). Osteology and comparisons. Palaeontographica, A, **185**: 85–180.