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SHORT COMMUNICATION

New saurischian dinosaur footprints from the Lower Jurassic of Poland

Gerard GIERLIŃSKI and Grzegorz NIEDŹWIEDZKI

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New Early Jurassic material of saurischian dinosaur footprints has been found in the coastal siliciclastic deposits of the Holy Cross Mountains. Seven specimens of medium-sized footprints, assigned to *Anchisauripus* sp., are reported from the upper Hettangian deposits at the Zapniów clay pit. Other finds of small-sized theropod footprints, identified as *Grallator* sp., were discovered in a new tracksite at the Śmiłów quarry, where the tracks are reported for the first time in the Polish Pliensbachian. Large theropod footprints of *Kayentapus* were first found at the upper Gromadzice site (deltaic deposits), and in Gliniany Las (barrier-lagoonal deposits), while the first Polish find of *Otozoum* came from the lower Gromadzice site (delta plain deposits).

Gerard Gierliński, Polish Geological Institute, Rakowiecka 4, PL-00-975 Warszawa, Poland, e-mail: gierlinski@yahoo.com; Grzegorz Niedźwiedzki, Department of Zoology, Faculty of Biology, University of Warsaw, Banacha 2, PL-02-097 Warszawa, Poland, e-mail: GrzegorzNiedzwiedzki@poczta.net-line.pl *(received: March 31, 2004; accepted: October 15, 2004).*

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INTRODUCTION

In the Zapniów clay pit (Fig. 1) near Przysucha (upper Hettangian Przysucha Ore-bearing Formation; Pieńkowski, 2004), dinosaur footprints were first discovered by Pieńkowski and Gierliński in 1987 (Muz. PIG 1572.II.2, specimen of ornithischian footprint described as *Moyenisauropus* sp.). Later, only an isolated and poorly preserved *Anchisauripus* footprint (Muz. PIG 1560.II.35) was identified at this site (Gierliński, 1995*a*; see also Gierliński and Pieńkowski, 1999). In June 2002, a track-bearing surface was exposed in this locality. Seven specimens of *Anchisauripus* footprints are preserved on a recently exposed sandstone in the mine driveway leading to the front face of the Zapniów clay pit (Fig. 2).

Other material described herein came from a newly discovered locality at Śmiłów quarry (Fig. 1) of so-called Szydłowiec Sandstones (upper Pliensbachian Drzewica Formation; Pieńkowski, 2004). Numerous very small theropod footprints of *Grallator* occur there on an isolated block (Fig. 3).

Other new material, *Kayentapus* footprints (Muz. PIG OS-221/35C, MNTS GG/18), were found at the upper Gromadzice site (Fig. 4) and Gliniany Las (Fig. 5A). The upper Gromadzice outcrop (Fig. 1) of deltaic middle Hettangian deposits of the Skłoby Formation (Pieńkowski, 1991, 2004; Gierliński and Pieńkowski, 1999; Gierliński *et al*., 2001) previously revealed ornithischian footprints of *Moyenisauropus natator* Ellenberger, 1974 (Gierliński *et al*., 2001) and small footprints of diminutive or juvenile sauropods (Gierliński, 1997). The Gliniany Las outcrop (Fig. 1) contains deposits of the large deltaic-barrier-lagoon sequence of the upper Hettangian Przysucha Ore-bearing Formation (Gierliński and Pieńkowski, 1999). The dinosaur footprints from Gliniany Las were the subject of numerous papers (Karaszewski, 1969, 1975; Gierliński and Potemska, 1987; Gierliński, 1990, 1991, 1996*b*, 1999; Gierliński and Sabath, 1998; Gierliński and Pieńkowski, 1999; Niedźwiedzki and Niedźwiedzki, 2001, 2004; Gierliński and Niedźwiedzki, 2002; Niedźwiedzki, 2003). Hitherto, only poorly preserved *Kayentapus* footprint (Muz. PIG 1560.II.19; Fig. 5B), described previously as *Grallator* (*Eubrontes*) sp. (Gierliński, 1990), were discovered at this tracksite.

The last find reported herein, the *Otozoum* footprint (Fig. 6), came from the lower Gromadzice site (lower-middle Hettangian Zagaje Formation), where an ichnoassemblage with numerous *Moyenisauropus* footprints was discovered (Gierliński and Pieńkowski, 1999; Niedźwiedzki and Niedźwiedzki, 2001, 2004).

In the Zapniów site footprints are preserved as natural molds and were found on the upper surface of a very thick sandstone, which represents the strand-line deposits of a wide-

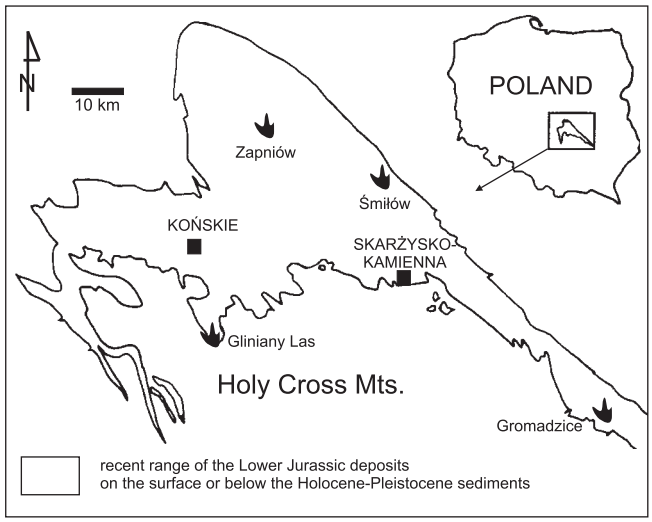

Fig. 1. Location of Gliniany Las, Zapniów, and Śmiłów tracksites on the northern slope of the Holy Cross Mts.

spread basin. It was a sandy barrier system separating shallow lagoons (Pieńkowski and Gierliński, 1987).

The footprints from the Śmiłów quarry are preserved as natural moulds on sandstone, which is of eolian origin as it was postulated by Karaszewski (1962), Karaszewski and Kopik (1970). Pieńkowski (2004) interpreted these strata as shoreline deposits with extensive coastal dune system. Thus it seems that the footprints were left on the coastal dune field.

The specimens from Gromadzice and Gliniany Las are preserved as isolated natural casts.

Plaster casts of specimens from Zapniów and Śmiłów, and *Otozoum* footprint from the lower Gromadzice site, are housed in the Geological Museum of Polish Geological Institute in Warsaw, Poland (abbreviation: Muz. PIG). The new Gliniany Las specimen of *Kayentapus* is housed in the collection of Hanna Wojda, while the Gromadzice *Kayentapus* specimens are protected in the Geological Museum of the Holy Cross Mts. Branch of the Polish Geological Institute in Kielce, Poland (abbreviation: Muz. PIG OS) and the Museum of Nature and

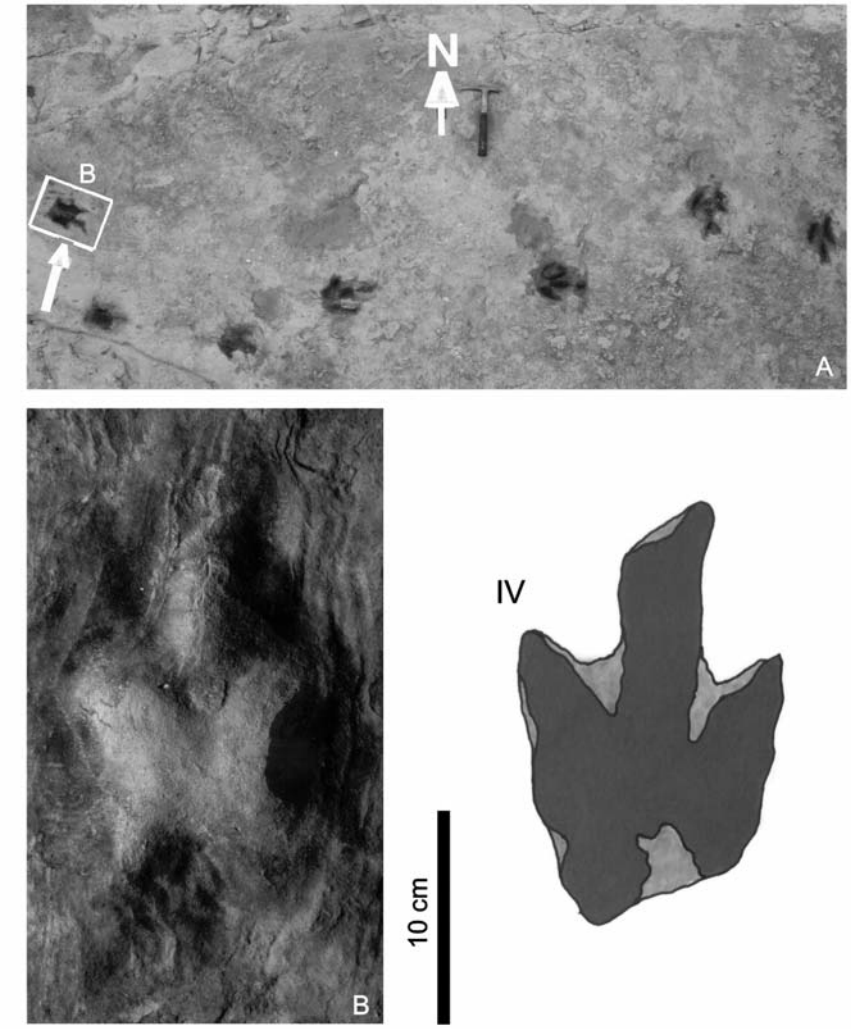

Fig. 2. *Anchisauripus* sp. from the Przysucha Ore-bearing Formation (upper Hettangian) of Zapniów site

A — whole surface with footprints; **B** — Muz. PIG 1688.II.1

Technology (former Museum of History of Material Culture) in Starachowice (abbreviation: MNTS GG).

ANCHISAURIPUS FOOTPRINTS FROM ZAPNIÓW

Footprints (Fig. 2) are tridactyl, medium-sized with third digit the longest, 18.5–23 cm long and 12–15 cm wide (one of these footprints Muz. PIG 1688.II.1 has been cast). Digit II is the shortest in all examples discovered on the footprint surface; digits III and IV are near subequal in length. Their length ratios measured according to the method of Olsen *et al*. (1998) equal: III/II = 1.44–1.78 and III/IV = 0.90–1.15. The angles between digits equal: II–III = 12–17°; III–IV = 13–19°; II–IV = 15–36°. According to the method of Weems (1992), the pedal measurement ratios are: te/fw = 0.56–0.69; (fl-te)/fw = 1.06–1.21.

Applying the method of measurement of Olsen *et al*. (1998), digit length ratios of the Zapniów tracks nearly fit those of the Newark *Anchisauripus* samples. Weems' measurement ratios for our specimens correspond to those of *Anchisauripus tuberosus* and *A. minusculus sensu* Weems.

GRALLATOR SP. FOOTPRINTS FROM ŚMIŁÓW

The footprints from Śmiłów (Fig. 3) are small-sized, tridactyl and relatively narrow forms. The specimen Muz. PIG 1688.II.2 (plaster cast of the best preserved print among numerous footprints, which was left in the field) is only 10.5 cm long and 6 cm wide. The angles between digits equal: II–III = 9°; III–IV = 23°; II–IV = 32°. The digit length ratios (according to the method of Olsen *et al*., 1998) are: III/II = 1.32; III/IV = 0.87. These ratios are similar to those of the *Stenonyx*-like ichnite (Muz. PIG 1560.II.23) from the Przysucha Ore-bearing Formation at Gliniany Las (Gierliński and Niedźwiedzki, 2002). However, "classic" *Stenonyx* from Massachusetts and

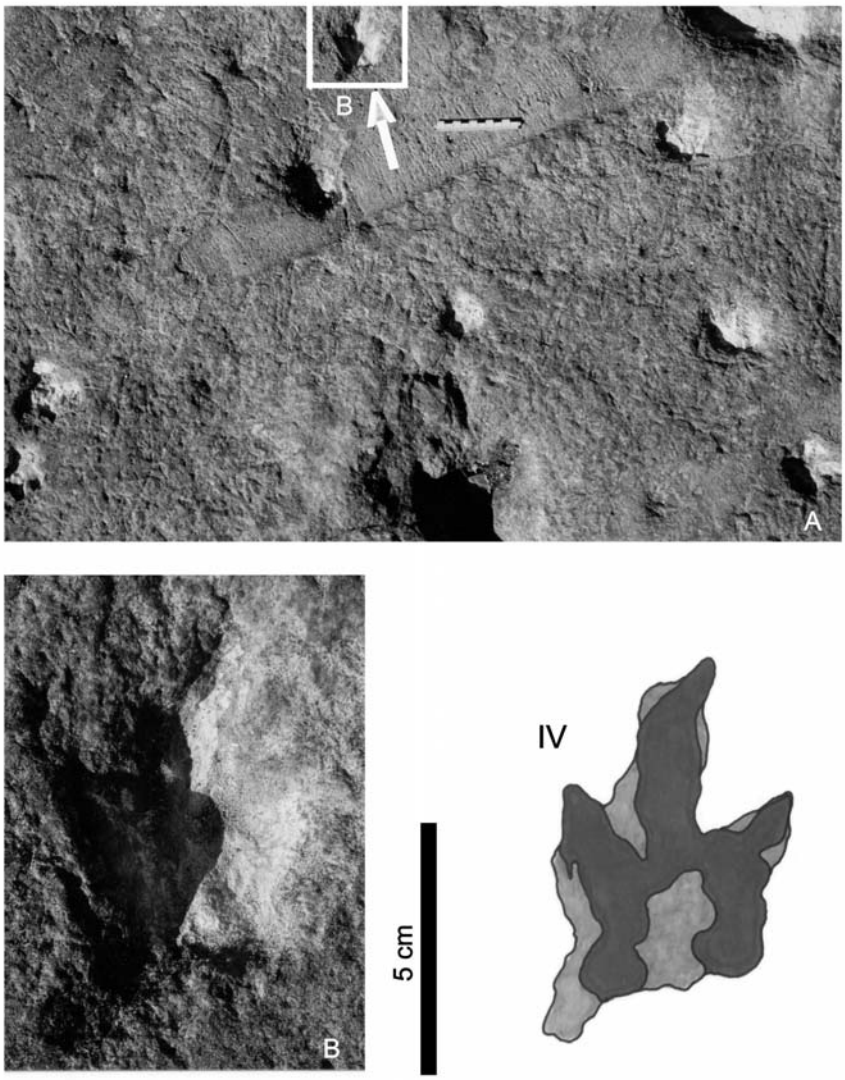

Fig. 3. *Grallator* sp. from the Drzewica Formation (upper Pliensbachian) of Śmiłów site

A — surface with numerous footprints preserved as natural molds; **B** — Muz. PIG 1688.II.2

Utah differs from the Śmiłów specimen by being V-shaped with the proximal pad located below the middle toe.

KAYENTAPUS FOOTPRINTS FROM GROMADZICE

Both footprints (Fig. 4) are similar in size, 23–24 cm long and 18–21 cm wide. The ichnites demonstrate the typical morphology of *Kayentapus* Welles, 1971, a medium to large grallatorid with narrow and highly divaricated digits. The specimens show digit divarication as follow: II–III = 18–28°, III–IV = 40–27°, II–IV = 58–55°. Their length ratios measured according to the method of Olsen *et al*. (1998) equal: III/II = 1.44–1.28 and III/IV = 0.93–0.85, thus fitting those of the foot of *Dilophosaurus wetherilli* Welles, 1970 (Olsen *et al*., 1998; see also Gierliński and Ahlberg, 1994). According to the method of Weems (1992), the pes measurement ratios are: te/fw = 0.41and 0.45; (fl-te)/fw = 0.78 and 0.84. Such ratios fit those of *Kayentapus hopii*, as well as *Eubrontes giganteus sensu* Weems (1992).

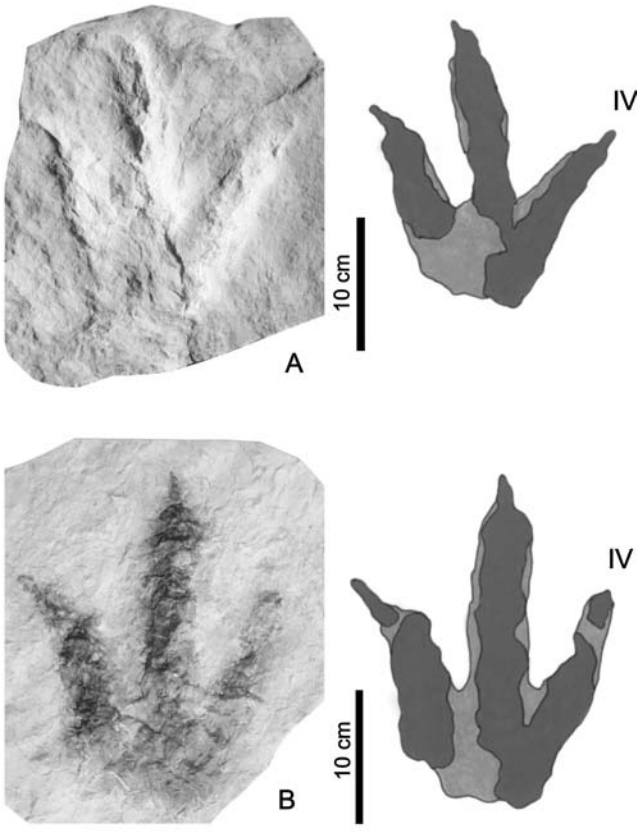

Fig. 4. *Kayentapus* sp. from the Skłoby Formation (middle Hettangian) of the upper Gromadzice site

A — MNTS GG/18; **B** — Muz. PIG OS-221/35C

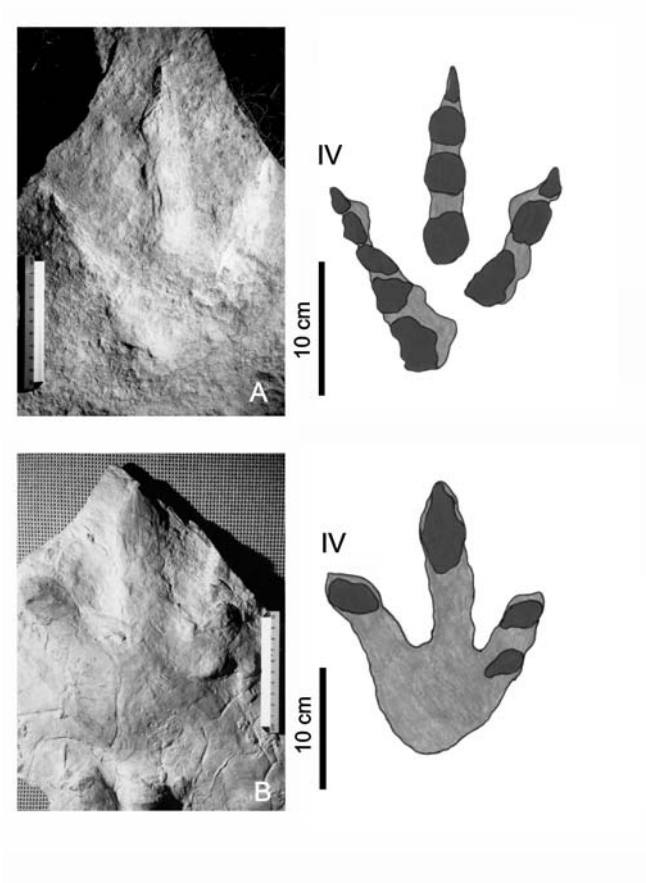

Fig. 5. *Kayentapus* sp. from the Przysucha Ore-bearing Formation (upper Hettangian) of Gliniany Las site

A — new specimen; **B** — Muz. PIG 1560.II.19

KAYENTAPUS FOOTPRINT FROM GLINIANY LAS

The footprint (Fig. 5A) is 27 cm long and 18.5 cm wide. The ichnite like the above discussed ones shows a morphology characteristic for the ichnogenus *Kayentapus*. Digits are narrow, III and IV subequal in length. In all digits claw impressions are clearly visible. Digit length ratios measured according to the method of Olsen *et al*. (1998) equal III/II = 1.34 and III/IV = 0.92. The angles between digits are: II–III = 27°; III–IV = 30°; II–IV = 57°. According to the method of Weems (1992), the pes measurement ratios are: te/fw = 0.53; (fl-te)/fw = 0.87.

This new *Kayentapus* specimen from Gliniany Las (Fig. 5A) demonstrates the presence of this ichnotaxon in the Przysucha Ore-bearing Formation, which was previously only inferred based on the poorly preserved footprint Muz. PIG 1560.II.19 (Fig. 5B).

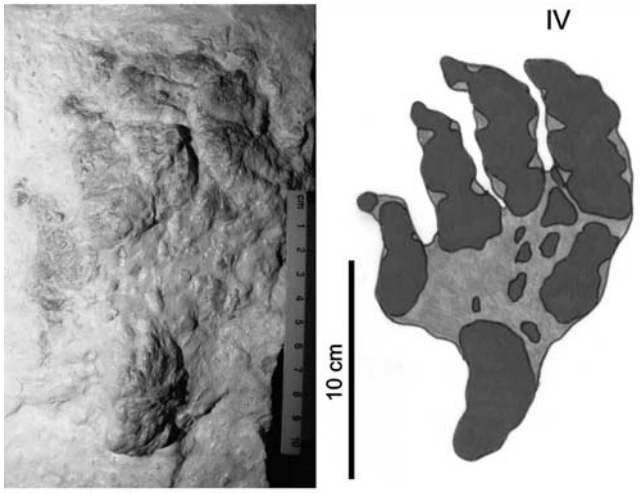

Fig. 6. *Otozoum* cf. *pollex* Rainforth, 2003, Muz. PIG 1560.II.66, from the Zagaje Formation (lower-middle Hettangian) of the lower Gromadzice site

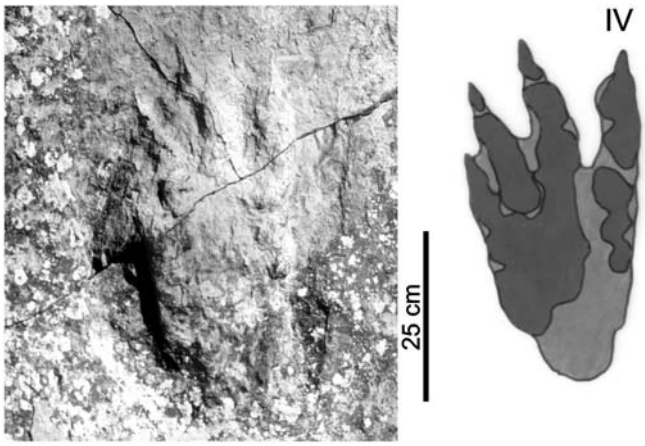

Fig. 7. *Otozoum*-like footprint of *Macropodosaurus gravis* Zakharov, 1964, from the Albian of Shirabad Suite in Tadzhikistan

OTOZOUM FOOTPRINT FROM GROMADZICE

The footprint (Fig. 6) is 17 cm long and 12 cm wide, with four anteriorly directed and medially curved digits. Digit III is the longest, 8.4 cm long, while digit I is the shortest, 6.4 cm long. Digits II and IV are subequal in length and slightly shorter than digit III. The specimen show digit divarication as follows: I–II = 7°; II–III = 4°; III–IV = 9°. In all digits, claw marks are clearly visible and subtriangular in shape. The relatively small size and narrow shape of this footprint resembles *Otozoum* cf. *pollex* Rainforth, 2003 from the Lower Jurassic of Lesotho.

The morphology of *O. pollex* resembles *Macropodosaurus gravis* Zakharov, 1964 (Fig. 7), an enigmatic track from the Lower Cretaceous of Tadzhikistan, more than any other ichnotaxon. Haubold (1971, 1984) considered *Macropodosaurus* a theropod track, McCrea *et al*. (2001) supposed their ankylosaur origin, while A. G. Sennikov (2002 pers. comm.) suspected rather a segnosaur (therezinosaur) affinity of their trackmaker. On the other hand, *Otozoum* is traditionally one of the most problematic vertebrate ichnite referred to prosauropods (e.g. Lull, 1953), non-dinosaurian archosaurs (e.g. Olsen and Galton, 1984), ornithopods (Thulborn, 1990), and thyreophorans (Gierliński, 1995*b*). In our opinion the origin of *Otozoum* is still not solved. As noted by M. Lockley (1998 writt. comm.), *Otozoum* is marked by a highly segmented pattern of the foot, which seems theropod-like. Thus, if the mandibular ramus from the Lower Jurassic of China, which was described by Xu *et al*. (2001), indeed belongs to an Early Jurassic segnosaur, the Therezinosauria should be also included among the candidates of *Otozoum* trackmakers.

Alternatively, given the recent data from Italy, *Otozoum* fits in-between gracile Late Triassic track of *Evazoum* Nicosia et Loi, 2003 (matching the foot of a small prosauropod *Sellosaurus*) and a robust, and more sauropodomorph-like Early Jurassic *Lavinipes* Avanzini, Leonardi et Mietto, 2003. Therefore, the similarity of *Macropodosaurus* to *Otozoum* is due to the convergence of segnosaur and prosauropod feet.

REFERENCES

AVANZINI M., LEONARDI G. and MIETTO P. (2003) — *Lavinipes cheminii* ichnogen., ichnosp. nov., a possible sauropodomorph track from the Lower Jurassic of the Italian Alps. Ichnos, **10**: 179–193.

GIERLIŃSKI G. (1990) — First find of a carnosaur footprint in the Lower Jurassic deposits of Gliniany Las, Holy Cross Mountains (in Polish with English summary). Prz. Geol., **38** (7–8): 315–317.

GIERLIŃSKI G. (1991) — New dinosaur ichnotaxa from the Early Jurassic of the Holy Cross Mountains, Poland. Palaeogeogr., Palaeoclimat., Palaeoecol., **85** (1–2): 137–148.

GIERLIŃSKI G. (1995*a*) — New theropod tracks from the Early Jurassic strata of Poland. Prz. Geol., **43** (11): 931–934.

GIERLIŃSKI G. (1995*b*) — Thyreophoran affinity of *Otozoum* tracks. Prz. Geol., **43** (2): 123–125.

GIERLIŃSKI G. (1996*a*) — Dinosaur ichnotaxa from the Lower Jurassic of Hungary. Geol. Quart., **40** (1): 119–128.

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

GIERLIŃSKI G. (1997) — Sauropod tracks in the Early Jurassic of Poland. Acta Palaeont. Pol., **42** (4): 533–538.

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

GIERLIŃSKI G. and AHLBERG A. (1994) — Late Triassic and Early Jurassic dinosaur footprints in the Höganäs Formation of southern Sweden. Ichnos, **3**: 99–105.

GIERLIŃSKI G. and NIEDŹWIEDZKI G. (2002) — Enigmatic dinosaur footprints from the Lower Jurassic of Poland. Geol. Quart., **46** (4): 467–472.

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

GIERLIŃSKI G. and POTEMSKA A. (1987) — Lower Jurassic dinosaur footprints from Gliniany Las, northern slope of the Holy Cross Mountains, Poland. N. Jahr. Geol. Paläont. Abh., **175** (1): 107–120.

GIERLIŃSKI G. and SABATH K. (1998) — Protoavian affinity of the *Plesiornis* trackmaker. J. Vertebrate Paleont., **18** (supplement to number, 3): 46A.

GIERLIŃSKI G., GAŹDZICKA E., NIEDŹWIEDZKI G. and PIEŃKOWSKI G. (2001) — New ornithischian dinosaur footprints in the Jurassic of Poland. Geol. Quart., **45** (2): 205–210.

HAUBOLD H. (1971) — Ichnia *Amphibiorum* et *Reptiliorum fossilium*. In: Handbuch der Paläoherpetologie (ed. O. Kuhn). Teil **18**. Gustav Fischer Verlag. Jena.

HAUBOLD H. (1974) — Die fossilen Saurierfährten. A. Ziemsen-Verlag. Wittenberg, Lutherstadt.

KARASZEWSKI W. (1962) — The stratigraphy of the Lias in the northern Mesozoic zone surrounding the Święty Krzyż Mountains (Central Poland) (in Polish with English summary). Pr. Inst. Geol., **30** (3): 333–416.

KARASZEWSKI W. (1969) — Track of reptilia in the Lower Liassic of the Świętokrzyskie Mountains, Middle Poland (in Polish with English summary). Kwar. Geol., **13** (1): 115–120.

KARASZEWSKI W. (1975) — Footprints of pentadactyl dinosaurs in the Lower Jurassic of Poland. Bull. Acad. Pol. Sc. Sér Sc. Terre, **23** (2): 133–136.

KARASZEWSKI W. and KOPIK J. (1970) — Lower Jurassic (in Polish with English summary). Pr. Inst. Geol., **56**: 65–98.

LULL R. S. (1953) — Triassic life of the Connecticut Valley. Bull. Connecticut State Geol. Nat. Hist. Surv., **181**.

MCCREA R. T., LOCKLEY M. G. and MEYER C. A. (2001) — Global distribution of purported ankylosaur track occurrences. In: The Armored Dinosaurs (ed. K. Carpenter): 413–454. Indiana University Press. Bloomington.

NICOSIA U. and LOI M. (2003) — Triassic footprints from Lerici (La Spezia, northern Italy). Ichnos, **10**: 127–140.

NIEDŹWIEDZKI G. (2003) — Sitting dinosaur track from the Lower Jurassic deposits of Poland (in Polish with English summary). Prz. Geol., **51** (12): 1041–1044.

NIEDŹWIEDZKI G. and NIEDŹWIEDZKI D. (2001) — Dinosaur tracks with metatarsal impressions from the Early Jurassic strata of Poland (in Polish with English summary). Prz. Geol., **49** (7): 649–650.

NIEDŹWIEDZKI G. and NIEDŹWIEDZKI D. (2004) — New finds of dinosaur tracks with metatarsal impressions from the Early Jurassic strata of Poland (in Polish with English summary). Prz. Geol., **52** (3): 237–242.

OLSEN P. E. and GALTON P. (1984) — A review of the reptile and amphibian assemblages from the Stromberg of southern Africa, with special emphasis on the footprints and the age of the Stromberg. Paleont. Africana, **25**: 87–110.

OLSEN P. E., SMITH J. B. and MCDONALD N. G. (1998) — 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** (3): 586–601.

PIEŃKOWSKI G. (1991) — Eustatically-controlled sedimentation in the Hettangian-Sinemurian (Early Liassic) of Poland and Sweden. Sedimentology, **38**: 503–518.

PIEŃKOWSKI G. (2004) — The epicontinental Lower Jurassic of Poland. Spec. Pap., Państw. Inst. Geol., **12**.

PIEŃKOWSKI G. and GIERLIŃSKI G. (1987) — New finds of dinosaur footprints in Liassic of the Holy Cross Mountains and its palaeoenvironmental background (in Polish with English summary). Prz. Geol., **35** (4): 199–205.

RAINFORTH E. C. (2003) — Revision and re-evaluation of the Early Jurassic dinosaurian ichnogenus *Otozoum*. Palaeontology, **46** (4): 803–838.

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: Proceedings 26th Forum on the Geology of Industrial Minerals (ed. P. C. Sweet). Virginia Division of Miner. Res. Publ., **119**: 113–127. Charlottesville.

XU X., XIJIN Z. and CLARK J. M. (2001) — A new therizinosaur from the Lower Jurassic Lower Lufeng Formation of Yunnan, China. J. Verterbrate Palaeont., **21** (3): 477–483.

ZAKHAROV S. A. (1964) — On the Cenomanian dinosaur, the tracks of which were found in the Shirkent River Valley (in Russian). In: Paleontology of Tadzhikistan (ed. V. M. Reiman): 31–35. Dushanbe, Ajaden-nuta Bayi. Tadzhikistan S.S.R.