New saurischian dinosaur footprints from the Lower Jurassic of Poland

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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, 1995a; 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 Śmliów 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, 1996b, 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-
spread basin. It was a sandy barrier system separating shallow lagoons (Pieńkowski and Gierliński, 1987).

The footprints from the Śmiałów 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 Śmiałów, 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

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

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**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
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 Śmilów (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 = 13–19°; II–IV = 15–36°. 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
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 = 0.41 and 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).

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**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).
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 shows 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. 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, 1995b). 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


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