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EARLY CRETACEOUS BIRD TRACKS FROM THE TETORI GROUP, FUKUI PREFECTURE, JAPAN

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ABSTRACT

Cretaceous bird tracks of a new ichnotaxon, *Aquatilavipes izumiensis* ichnosp. nov., is described. On two blocks, thirty-seven tracks were recovered from the terrestrial sediments of the Early Cretaceous (Berriasian-Valanginian) Tetori Group, Central Japan. The average length of the tracks is 37.7 mm and the average width is 44.5 mm. The average divarication is 120°, and the ratio of length to width is 0.83 on average, suggesting that the tracks were made by birds. The new taxon *Aquatilavipes izumiensis* is the oldest known bird ichnospecies in eastern Asia.

Key words: bird track, Tetori Group, Early Cretaceous, Itsuki Formation

東　洋一・荒川洋平・冨田幸光・フィリップ J. カリー (2002) 手取層群からの白亜紀前期鳥類足跡．福井県立恐竜博物館紀要 1 : 1-6.

新印跡動物として *Aquatilavipes izumiensis* ichnosp. nov. が白亜紀の鳥類足跡として記載された．37個の足跡が保存された二個の岩塊が，手取層群の白亜紀前期（ベリアシアン～ヴァランギニアン）陸成堆積層から発見された．これらの足跡の平均足印長は 37.7 mmで，平均足印幅は 44.5 mmであるまた，平均総指間角が120°，足印長と足印幅の比が 0.83 であり鳥類の足跡であることがわかる．*Aquatilavipes izumiensis* は，アジア地域で確実に最も古い鳥類足跡化石である．

INTRODUCTION

In June 7th, 1987, Mr. Masami Chiba, Dr. Kiichiro Hachiya, and Mr. Masayuki Umemoto discovered two slabs preserving Cretaceous bird tracks on the talus-covered cliff on the left bank of the Itoshiro River in Izumi Village, Fukui Prefecture, Central Japan.

In this area, the Tetori Group, which is of Middle Jurassic to Early Cretaceous age, is widely distributed (Fig. 1). The Tetori Group in this region is subdivided into three subgroups, the Kuzuryu, Itoshiro, and Akaiwa Subgroups in ascending order (Maeda, 1961). Detailed stratigraphy of the Tetori Group in the vicinity Izumi Village was discussed by Maeda (1952, 1957), Kawai et al. (1957), and Yamada et al. (1989). The upper part of the Itoshiro Subgroup yields brackish to fresh water molluscs such as *Ostrea, Myrene, Tetoria* and *Viviparus* (Tamura, 1990).

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The bird tracks were found in the Itsuki Formation, correlating to the upper part of the Itoshiro Subgroup in the Izumi region. The cliff yielding the bird tracks consists of coarse sandstone and alternating beds of medium to fine sandstone and shale (Fig. 2).

SYSTEMATIC PALEONTOLOGY

Class AVES
Ichnofamily AVIPEDIDAE Sarjeant and Langston, 1994
Ichnogenus AQUATILAVIPES Currie, 1981
AQUATILAVIPES IZUMIENSIS ichnosp. nov.
(Figs. 3-4; Table 1)

Etymology: The specific name refers to Izumi Village in Fukui Prefecture.

Holotype: Thirty seven footprints are preserved as natural casts on two black sandy shale slabs as FPDM-V43 and FPDM-V44, respectively. Track 1 (Figs. 3, 4) on the slab FPDM-V43 (Fukui Prefectural Dinosaur Museum) is designated as the

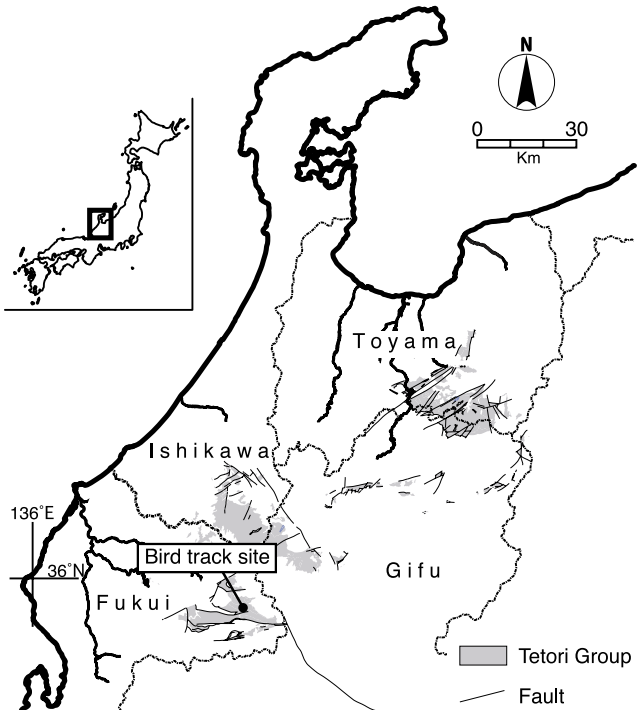

FIGURE 1. Map showing the distribution of the Tetori Group in the Hokuriku district of Central Japan, and the bird track locality.

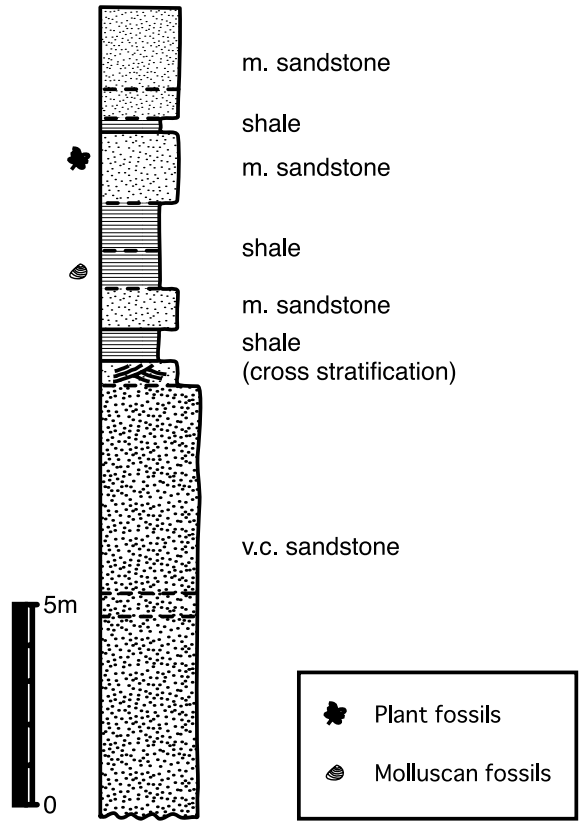

FIGURE 2. Stratigraphic section showing the bird track-bearing horizon.

holotype.

Horizon and Locality: Itsuki Formation, upper part of the Itoshiro Subgroup; Early Cretaceous (Berriasian-Valanginian). A cliff on the left bank of Itoshiro River in Izumi Village, Fukui Prefecture (Lat. 35˚55'37"N, Long. 136 ˚41'30"E).

DIAGNOSIS

Small footprints, shorter than 38 mm in length, with slender digits. The greatest width of digit III is around 17% of its length in the holotype, although others can be relatively wider (around 20% to 25%). Digit II is approximately 60% the length of digit III, and digit IV is 80%. Each digit narrows distally into a sharp claw impression. Digit II curves inward distally and digit IV outward. The total width between the tips of digits II and IV is on average 19% greater than the length and average divarication between digits II and IV is 120˚. The angle between digits II and III is less than that between digits III and IV. Digital pads are present on all toes (two on digit II and three on digits III and IV).

DESCRIPTION

The footprints are tridactyl and small in size, and each digit is slender with digital pad impressions. The holotype (Track 1 in Fig. 3) was made by a left foot and is 39 mm long by 45.4 mm wide. Digit II is 18.3 mm long and 3.9 mm at its widest point. The length of digit III is 30.6 mm and the greatest width is 5.4 mm. Digit IV is 24.6 mm long and 4.6 mm wide. The divarication between the second and fourth digits is 111˚, between digits II and III is 45˚, and between III and IV is 65˚. Digit II curves inward anterolaterally, but digit IV curves outward laterally. Small triangular claw impressions are preserved on the ends of all digits. Three digits (II, III, IV) are connected proximally to each other, and a distinct "heel" impression is present, but there are no indications of a hallux or webbing between the toes. There are three distinct digital pads beneath each of digits III and IV, and at least two on the bottom of the second toe.

The average length and width of the seventeen tracks are 37.7 mm and 44.5 mm respectively; the length-width ratio is 0.85. The average divarication of digits II and IV of sixteen tracks is 120˚.

TABLE 1. Measurements of *Aquatilavipes izumiensis* ichnosp. nov.

Specimen Number	Track Number	Footprint Length (mm)	Footprint Width (mm)	Ratio FL/ FW	Digit Length (mm)			Divarication (°)		
					II	III	IV	II-III	III-IV	Total
FPDM-V43	1(track 2)	37.9	47.1	0.80	18.4	29.6	23.2	48.0	68.5	116.5
	2	43.8	35.8	1.22	12.2	35.1	22.5	48.0	60.0	108.0
	3	37.2	46.6	0.80	18.5	31.5	22.6	45.0	80.5	125.5
	4(track 1)	39	45.4	0.86	18.3	30.6	24.6	45.0	65.0	111.0
	5	40.8	47.2	0.86	20.3	33.8	23.5	56.0	66.0	122.0
	6	34.3	49.8	0.69	19.7	28.9	24.2	64.5	66.5	131.0
	7	35.3	42.2	0.84	16.4	29.7	22.9	44.0	77.0	121.0
	8	33.4	44.0	0.76	15.9	27.7	22.5	61.5	80.0	141.5
	9	39.2	36.3	1.08	15.6	27.9	18.7	47.0	62.0	109.0
	10	43.7	40.8	1.07	15.5	32.7	22.8	55.0	40.0	95.0
	11	38.8	44.0	0.88	23.3	33.7	21.4	45.5	69.5	115.0
	12	31.9	45.6	0.70	15.5	26.7	21.9	71.0	80.5	151.5
	13(track 3)	40.5	48.6	0.83	19.8	31.3	24.2	53.5	68.0	121.5
	14	36.5	44.5	0.82	17.8	28.9	21.9	51.5	57.5	109.0
	15	34.0	40.0	0.85	18.2	27.2	23.0	49.0	62.0	111.0
FPDM-V44	B-1	40.5	51.5	0.79	19.8	30.8	22.6	71.0	75.0	146.0
	B-2	34.3	46.5	0.74	20.1	27.8	24.2	42.0	65.5	107.5
	Average	37.7	44.5	0.86	18.1	30.2	22.6	52.8	67.3	120.1

DISCUSSION

Aquatilavipes izumiensis is a new ichnite made by a tridactyl and digitigrade bird that was small in size, and had slender toes with distinct pads. There are no hallux or web impressions. The "heel" impression is distinct where the proximal ends of the three digits (II, III, IV) merge. Tiny claw impressions are preserved at the distal ends of all digits.

The footprints on both slabs are so densely concentrated that is difficult to separate individual trackways. Track 2, for example, was made by a right foot and may be next in sequence from Track 1, which is a left footprint. However, it is also possible that these two ichnites were made by two different individuals, and that the matching footprint for Track 2 is the one directly below Track 1 in Fig 3. Because there are no certain associations, we have not taken any pace or stride measurements. The extrapolated track density for the specimen of *Aquatilavipes izumiensis* (FPDM-V43; Fig. 3) is approximately 210 tracks / m^2 which is very similar to that of *A. swiboldae.* Densities of Korean bird tracks are lower than that of *A. izumiensis*; such as *Jindongornipes* with reported densities of 80 and 60 tracks / m^2 (Lockley et al., 1992). There are no invertebrate trace fossils associated with the track levels of the two slabs, and not surprisingly there are no marks that could be interpreted as being left by bird beaks.

Lockley et al. (1992) provide criteria to recognize fossil bird foot impressions, which are: (i) small size; (ii) slender digit impressions, with indistinct differentiation of pad impressions; (iii) wide divarication angle (about 110˚-120˚) between digits II and IV; (iv) a posteriorly directed hallux (digit I); (v) slender claws; (vi) distal curvature of outer (II and IV) claws away from central axis of foot; (vii) track density; (viii) associated fossils indicating feeding behavior. McCrea and Sarjeant (2001) suggested that the footprint length-width ratios of footprints are also useful to distinguish the bird tracks from dinosaur tracks. The ratios (FL/FW) of bird ichnotaxa are much lower than those of dinosaurian ichotaxa, about 1.0 or lower. McCrea and Sarjeant (2001) point out that the ratios (FL/FW) in footprints of the living birds *Charadrius vociferus* and *Ardea herodias* are 0.88 and 0.90 respectively, and those of *Aquatilavipes swiboldae* and *A. curriei* are 0.80 and 0.73. That also holds true for Asian bird ichnotaxa using data available in Lim et al. (2000), Yang et al. (1995), and Zhen et al. (1995): 0.76 in *Koreanaornis,* 0.81 in *Uhangrichnus,* 0.78 in *Hwangsanipes*, 0.83 in an unnamed webbed bird track form Korea, and 0.82 in *Aquatilavipes sinensis*. The footprint length-width ratio of *A. izumiensis* is 0.85 (N=17).

In contrast, the FL/FW ratios of bipedal dinosaur ichnotaxa from the Lower Cretaceous Gates Formation are 1.2 (*Irenesauripus*), 1.09 (*Ornithomimipus*), 1.19 (*Irenichnites*), and 1.19 in *Gypsichnites* (McCrea and Sarjeant 2001). Moratalla et al. (1988) concluded that the FL/FW ratio of theropod ichnotaxa is more than 1.25, and that of the ornithopod ichnotaxa is less than 1.25.

The average lengths and widths of *A. izumiensis* ichnites are about the same as those of *A. swiboldae*, but those of *A. curriei* are almost double *A. izumiensis* in size. *A. izumiensis* is clearly distinguishable from *A. curriei* not only by its smaller size but also by other morphological characteristics such as its narrower average divarication between digits II and IV, and the absence of a groove on the center of each digit. The average divarication of *A. izumiensis is* greater than that of *A. swiboldae*, and there is a greater disparity of lengths between digits II and IV.

Bird ichnotaxa reported from the Cretaceous terrestrial deposits of Korea and China are *Koreanaornis hamaensis* (Kim, 1969), *Jindongornipes kimi* (Lockley et al., 1992),

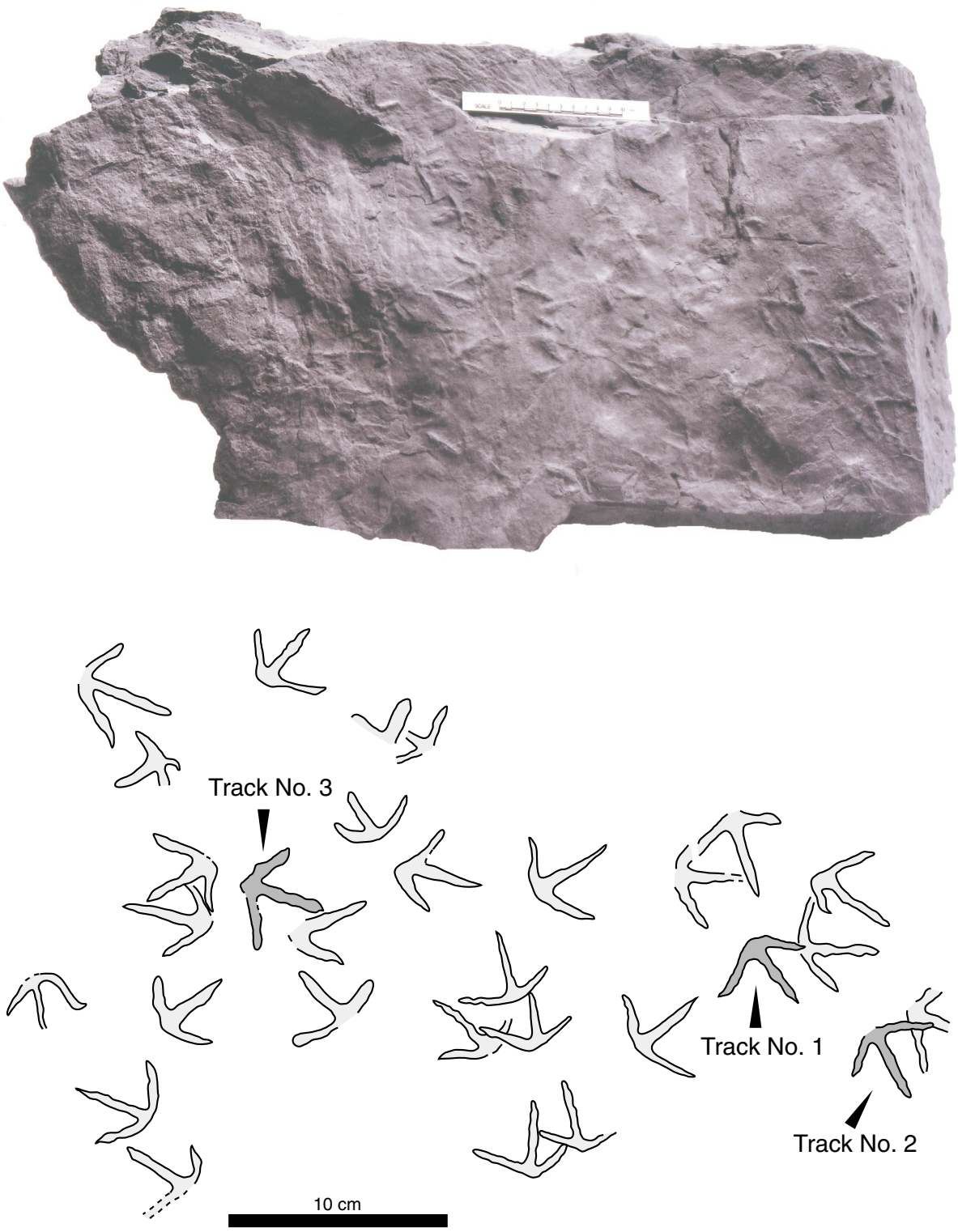

FIGURE 3. *Aquatilavipes izumiensis* ichnosp. nov. (FPDM-V43), natural cast of footprints.

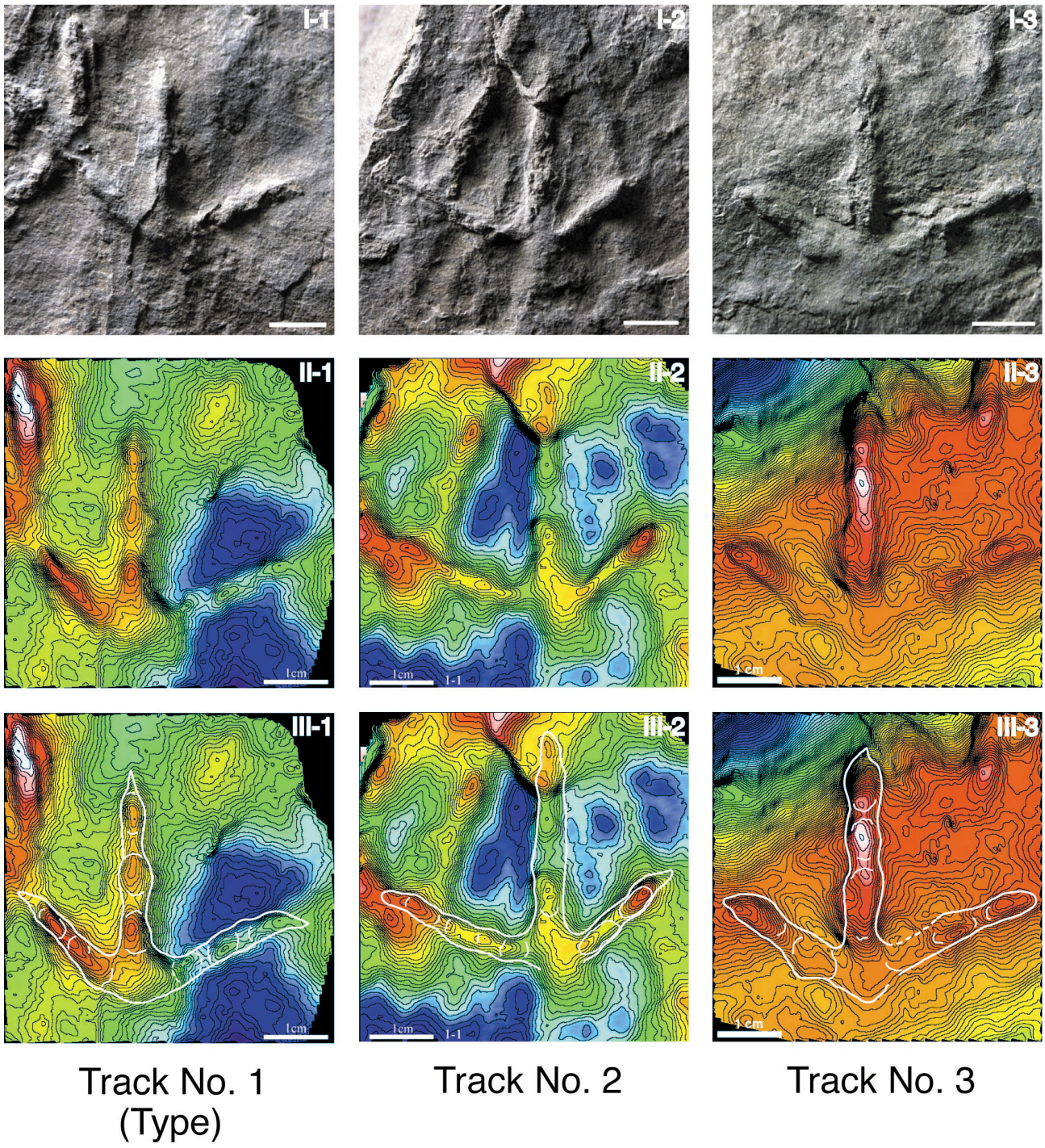

FIGURE 4. *Aquatilavipes izumiensis* ichnosp. nov. (FPDM-V43), photographs (**I-1** to **I-3**), topographic images (**II-1** to **II-3**), and topographic images with superimposed outline drawings (**III-1** to **III-3**). Topographic images are produced by the non-contact three-dimensional digitizer (VIVID700) and the software (3D-Rugle), following the procedure of Arakawa et al. in this volume. All photographs and topographic images are natural casts: track no. 1, left; track no. 2; right, track no. 3; left. All scales=10 mm.

Uhangrichnus chuni (Yang et al., 1995), *Hwangsanipes choughi* (Yang et al., 1995), and *Aquatilavipes sinensis* (Zhen et al., 1995). The morphological characteristics of *Koreanaornis* and *A. sinensis* are the separation of the proximal ends of digits II, III, and IV, and the absence of "heel" impressions. *Jindongornipes* is much larger than *A. izumiensis* and is tetradactyl. *Uhangrichnus* and *Hwangsanipes* are footprints made by web-footed birds. *A. izumiensis* can be clearly distinguished from all of these Asian Cretaceous bird ichnotaxa.

Aquatilavipes izumiensis is probably a primitive taxon of marsh-dwelling bird such as *A. swiboldae* and *A. curriei.* The depositional environment of the track-bearing beds was along the margin of alluvial fans, floodplains, and lagoons close to the mouth of a river (Azuma et al., 1992). The presence of the bird tracks suggests that the depositional environment of the track site was covered by no more than a few centimeters of quietly moving water, possibly at the margin of a lake. *A. izumiensis* from the Tetori Group is the oldest record of the bird tracks in eastern Asia.

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＜地名・地層名＞

Akaiwa Subgroup ……赤岩亜層群
Fukui ……福井
Itoshiro Subgroup……石徹白亜層群
Itsuki Formation ……伊月層
Izumi ……和泉
Kuzuryu Subgroup……九頭竜亜層群
Tetori Group ……手取層群