

sification of the oil and its cleavage by fungal lipase activity as well as their utilization for cell growth and production of cellular lipids. No marked changes were observed in the GL and PL fractions during these experiments.

Our investigation may give new insight into enhanced polymer conversion by the addition of acetate. These oil wastes may not only be effectively degraded by this fungus, but may also be converted into nutritious animal feed containing essential fatty acids such as linoleic acid and GLA. Further research is planned to elucidate the mechanisms underlying the conversion of polymers in different mixtures by *Mucor*. We hope that this will shed further light on the different reaction outcomes when acetate is added to the medium containing over-used frying oil.

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Jurassic bipeds that could hop? perch? pounce? fly?

D. Eduard van Dijk*

THE DESCRIPTION OF THE ICHNOGENUS *Molapentapodiscus* (Ellenberger, 1970) includes the presumption that forward progression was by bounding with feet together. That this genus, and other genera based on footprints or trackways, were hoppers, has been disputed. Material from KwaZulu-Natal, South Africa, suggests that more than one Lower Jurassic biped was a hopper, but with feet adapted also to other functions.

Bipedal leaping or hopping is known among mammals such as the kangaroo rat *Dipodomys* and the springhare *Pedetes*, and in birds such as sparrows and robins. No extant reptiles show this type of locomotion and interpretations of paired footprints as evidence for it in extinct reptiles have been disputed. The simultaneous thrusts of the hind-limbs of a buoyant animal has been invoked¹ as an alternative explanation of paired prints. In 1970, Ellenberger produced a summary² of

work in and around Lesotho in southern Africa, in which he briefly described, with drawings, more than a hundred kinds of animal footprints. These were left in part by species from two genera, which included *Molapentapodiscus* (*Dipodiscus*) *saltator* and *M. supersaltator*, and *Malutitetrapodiscus saltator*, which were interpreted as bipedal hoppers. Of these, *M. supersaltator* was identified from footprints from Giant's Castle, KwaZulu-Natal, apparently from photographs. The species differs from the two Lesotho species by having curved toes.

In 1978, a brief account in the journal *Palaeontologica africana*³ of footprints from Giant's Castle included illustrations and discussions of two fossil slabs with footprints interpreted as those of bipedal hoppers. In 1984, Olsen and Galton in the same journal⁴ reviewed the reptile and amphibian assemblages of the Stormberg (Upper Karoo; Upper Triassic to Lower Jurassic) of southern Africa, and placed a number of Ellenberger's ichnotaxa in synonymy, basing their concepts of his taxa only on publications. *Molapentapodiscus* was placed by them, together with Ellenberger's 1970 genera *Nanopodiscus* and *Plateotetrapodiscus*, and his 1974 genus *Suchopus*, in synonymy with *Batrachopus* Hitchcock, 1845, from Connecticut. (The name *Batrachopus*, incidentally, was used before Hitchcock in 1845 and may thus not be a valid name.) To judge from several accounts, e.g. Haubold,⁵ *Batrachopus* of Hitchcock is a quadrupedal

walker. Thulborn,⁶ on the other hand, in a critical examination of the hopping mode of locomotion in relation to trackways, accepts *Molapentapodiscus* as a hopper, while rejecting claims for this type of locomotion in the Upper Jurassic dinosaur *Saltosauropus* Demathieu & Gaillard, 1984. In his Fig. 9.4, he illustrated the feet and tracks of *Saltosauropus*, wallabies, birds, and *Molapentapodiscus*, which is represented by a foot and a composite sequence, with Ellenberger acknowledged as source. The foot can be identified as that of *M. supersaltator*.

A synthetic trackway of this species is illustrated in Fig. 1. The base of each footprint, which represents the distal ends of the metatarsals (sole of the foot), is rotated so that the toes arise progressively further backwards from innermost to outermost. The tips of the toes curve inwards, with the innermost almost straight. If the outermost toe is the fifth, and the first toe absent or failing to register, relationship to the archosaurs (including dinosaurs) is remote; if the outermost toe is the fourth, and the fifth absent or failing to register, a relationship to the archosaurs, in which bipedalism is common, is likely.

A fossil slab from Giant's Castle, illustrated in Fig. 5 of ref. 3, had, in addition to *M. supersaltator* prints, other tracks which indicated hopping locomotion. They are distinguished by a very long outer toe

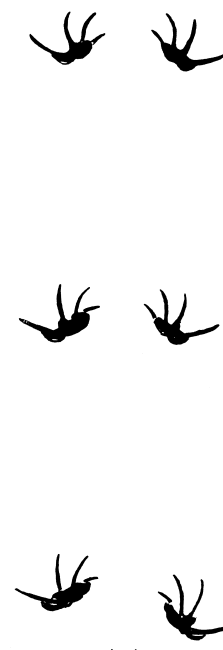


Fig. 1. Composite trackway of *Molapentapodiscus supersaltator* from Giant's Castle, South Africa. The diagram has been synthesized by repetition of two very clear underprints, those at bottom left and middle right in the diagram, replacing the two others on the left, which had the toes spoiled by overprinting, and completing the sequence on the right edge of the slab, where the one at the bottom was partial and that on the top missing. Stereo-photographs of the slab are available from the author. Scale bar = 1 cm.

*Department of Zoology, University of Stellenbosch, Private Bag X1, Matieland, 7602 South Africa. E-mail: eddie@vandijks.com

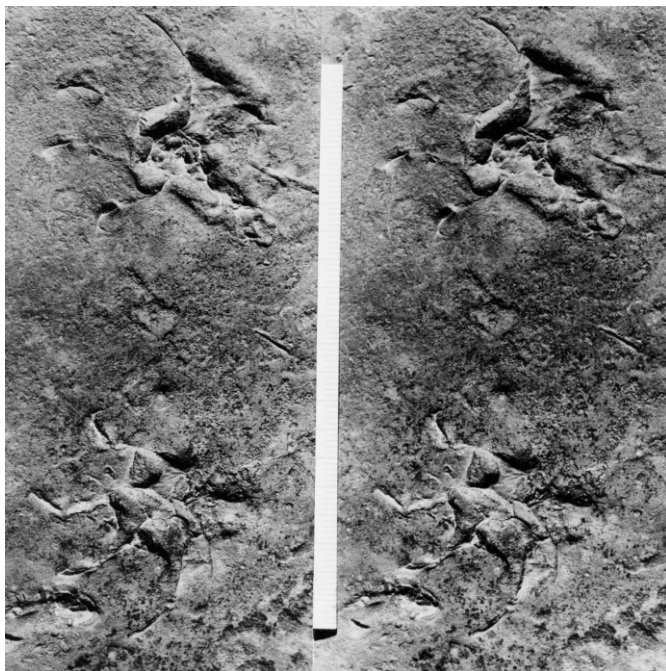


Fig. 2. Stereo-photographs of a pair of footprints of a bipedal hopper, attributed to *Molapopentapodiscus saltator*, from Giant's Castle, South Africa. Scale bar = 10 cm.

and three inner toes, the tips of which are strongly curved. A pair of footprints attributed to this second taxon was subsequently found on a small slab and is illustrated in Fig. 2.

The sediments at Giant's Castle have been interpreted as those of a playa lake,⁷ that is, a shallow body of water which forms quickly and yields mudflats during evaporation. The scenario in which paired prints are formed by buoyant animals is out of place in this environment. The paired prints at Giant's Castle are commonly associated with cracks in the sediment, which accords with observations that bird footprints initiate mudcracks⁸ on mudflats. The prints are common on the particular layers on which they occur, and vary in direction. Some prints were transmitted through

the upper layer (about 1 cm thick) onto the layer below, producing 'underprints'. On the same slab other prints have no underprints, which implies less plasticity due to evaporation, and supports the notion that they were exposed to the air. The multiplicity of prints suggests that the microenvironment was favourable for some activity such as searching for prey. The curved toes of both Giant's Castle taxa suggest some gripping function, such as perching, pouncing on prey, or climbing and clinging. Living bipedal hoppers and jumpers have one or two toes directed more or less directly forwards, and the feet are kept together. The curved-toed hoppers had feet which were further apart, the orientation of the toes suggesting that the force exerted had an inwards component. This is similar to

the alternate thrusts of ice-skaters, or the toe-out action when humans climb sand dunes. The presence of outwards-directed landing-marks behind footprints has been noted.³ This suggests that the feet move towards one another during passage through the air.

A hopping action appears to be inefficient on a yielding substrate, which is the kind of medium that is likely to register imprints. For the preservation of tracks, and their later exposure on bedding planes, the sediments must be discontinuous. The rarity of tracks that indicate hopping and jumping may be ascribed to the avoidance of discontinuous, yielding substrates by the animals concerned.

If these curved-toed bipeds were inefficient hoppers, their feet may have had some other function, such as perching, climbing, clinging or capturing prey. The possibility of flight, which is consistent with these functions, must then be considered.

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