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Investigation of an enigmatic trace fossil from the Miocene Taliao Formation, Taiwan

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Ichnology is the comprehensive study of trace fossils that encompasses morphology, ethology, and bioturbated textures. Being used extensively by geologists, ichnology has played an important role in identifying and reconstructing paleoenvironments. By decoding the secrets of trace fossils, geologists can further expand the knowledge of paleoenvironments.

In northeastern Taiwan, the early Miocene Taliao Formation (20-22Ma) is well exposed in several outcrops along the coast from the Yehliu peninsula to Badouzi promontory. Encased between the coal- bearing Mushan and the Shitih Formations, Taliao Formation represents a shallow marine environment influenced by storms.

At the Badouzi Promontory, multifarious trace fossils are widely distributed over the lower part of Yehliu member (Middle Taliao Formation) such as *Schaubcylindrichnus, Ophiomorpha,* or *Macaronichnus. It is noteworthy that* within certain sandstone beds, peculiar funnel-like burrows were observed. In cross section, a thin-lined shaft, 2-3 cm in diameter, penetrates vertically for about 70 - 80 cm before gradually bending to horizontal, giving it an overall J-shaped form. Also, some feather-like structures appear around the top of the shaft, but not in the deeper parts.

In order to gain a better understanding, the shaft was sectioned into several serial slabs which allowed the 3D morphology and architecture of the trace fossil to be assessed. On one specimen, Computed tomography (CT scanning) was also applied. After analysis of the burrow, we construct a likely 3D morphological model which suggests that the shaft can be divided into 4 parts: (1) Main burrow (2) Bioturbated region (3) Peripheral tube (4) Recumbent planes.

Lithology and sedimentary structures indicate that the tracemaker of these burrows lived in muddy sand substrate using an open burrow to feed. Also, the tracemaker must have been good at excavation, as it escaped from depositional events several times. We propose four competing ethological hypotheses: (1) Bivalves. In certain specimen, we found a siphon-like trace and a blurry shell imprint within the main burrow. However, the size of the burrow is disproportionate to the length in this hypothesis. (2) Shrimp. When excavating the tube, shrimp would use their limbs to push sediments aside and make a maze with bending tubes which resemble J-shape. Nevertheless, the evidence of the connections to other crustacean burrows is absent in these beds. (3) Soft-body organisms. Huge worms or echinoderms would use their tentacles to feed that might result in traces that are similar to recumbent plane structures. (4) Vertebrates. Some modern vertebrates like garden eels can make a curving funnel-like burrow that is similar to J-shaped burrow.

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