ix Acknowledgments

Introduction

3 Peter L. Falkingham, Daniel Marty, and Annette Richter

Part 1. Approaches and Techniques for Studying Dinosaur Tracks

- 1 Experimental and Comparative Ichnology
- 14 Jesper Milàn and Peter L. Falkingham

Close-Range Photogrammetry for 3-D Ichnology:

- 2 The Basics of Photogrammetric Ichnology
- 28 Neffra Matthews, Tommy Noble, and Brent Breithaupt

The Early Cretaceous Dinosaur Trackways in Münchehagen (Lower Saxony, Germany): 3-D Photogrammetry as Basis for Geometric Morphometric Analysis of Shape Variation

- 3 and Evaluation of Material Loss during Excavation
- 56 Oliver Wings, Jens N. Lallensack, and Heinrich Mallison
- 4 Applying Objective Methods to Subjective Track Outlines
- 72 Peter L. Falkingham

Beyond Surfaces: A Particle-Based

- 5 Perspective on Track Formation
- 82 Stephen M. Gatesy and Richard G. Ellis

A Numerical Scale for Quantifying the Quality

- 6 of Preservation of Vertebrate Tracks
- 92 Matteo Belvedere and James O. Farlow

Evaluating the Dinosaur Track Record: An Integrative Approach to Understanding the Regional and Global Distribution, Scientific Importance,

- 7 Preservation, and Management of Tracksites
- 100 Luis Alcalá, Martin G. Lockley, Alberto Cobos, Luis Mampel, and Rafael Royo-Torres

Part 2. Paleobiology and Evolution from Tracks

Iberian Sauropod Tracks through Time: Variations

- 8 in Sauropod Manus and Pes Morphologies
- 120 Diego Castanera, Vanda F. Santos, Laura Piñuela, Carlos Pascual, Bernat Vila, José I. Canudo, and José Joaquin Moratalla

The Flexion of Sauropod Pedal Unguals and Testing the

- 9 Substrate Grip Hypothesis Using the Trackway Fossil Record
- 138 Lee E. Hall, Ashley E. Fragomeni, and Denver W. Fowler

Dinosaur Swim Track Assemblages: Characteristics,

- 10 Contexts, and Ichnofacies Implications
- 152 Andrew R. C. Milner and Martin G. Lockley

Two-Toed Tracks through Time:

- 11 On the Trail of "Raptors" and Their Allies
- 182 Martin G. Lockley, Jerald D. Harris, Rihui Li, Lida Xing, and Torsten van der Lubbe

Diversity, Ontogeny, or Both? A Morphometric Approach to Iguanodontian Ornithopod (Dinosauria: Ornithischia) Track Assemblages from the Berriasian

- 12 (Lower Cretaceous) of Northwestern Germany
- 202 Jahn J. Hornung, Annina Böhme, Nils Schlüter, and Mike Reich

Uncertainty and Ambiguity in the

- 13 Interpretation of Sauropod Trackways
- 226 Kent A. Stevens, Scott Ernst, and Daniel Marty

Dinosaur Tracks as "Four-Dimensional Phenomena"

- 14 Reveal How Different Species Moved
- 244 Alberto Cobos, Francisco Gascó, Rafael Royo-Torres, Martin G. Lockley, and Luis Alcalá

Part 3. Ichnotaxonomy and Trackmaker Identification

Analyzing and Resolving Cretaceous Avian Ichnotaxonomy Using Multivariate Statistical

- 15 Analyses: Approaches and Results
- 258 Lisa G. Buckley, Richard T. McCrea, and Martin G. Lockley

Elusive Ornithischian Tracks in the Famous Berriasian (Lower Cretaceous) "Chicken Yard" Tracksite of Northern Germany: Quantitative Differentiation

- 16 between Small Tridactyl Trackmakers
- 310 Tom Hübner

Part 4. Depositional Environments and Their Influence on the Track Record

Too Many Tracks: Preliminary Description and Interpretation of the Diverse and Heavily Dinoturbated Early Cretaceous "Chicken Yard" Ichnoassemblage

- 17 (Obernkirchen Tracksite, Northern Germany)
- 334 Annette Richter and Annina Böhme

Dinosaur Tracks in Eolian Strata: New Insights into Track

- 18 Formation, Walking Kinetics, and Trackmaker Behavior
- 358 David B. Loope and Jesper Milàn

Analysis of Desiccation Crack Patterns for

- 19 Quantitative Interpretation of Fossil Tracks
- 366 Tom Schanz, Maria Datcheva, Hanna Haase, and Daniel Marty

A Review of the Dinosaur Track Record from Jurassic and Cretaceous Shallow Marine

- 20 Carbonate Depositional Environments
- 380 Simone D'Orazi Porchetti, Massimo Bernardi, Andrea Cinquegranelli, Vanda Faria dos Santos, Daniel Marty, Fabio Massimo Petti, Paulo Sá Caetano, and Alexander Wagensommer



Paleoenvironment Reconstructions of Vertebrate Tracksites in the Obernkirchen Sandstone, **Lower Cretaceous of Northwest Germany**

393 Jahn J. Hornung, Annette Richter, and Frederik Spindler

- **Dinosaur Track Terminology: A Glossary of Terms**Daniel Marty, Peter L. Falkingham, and Annette Richter 399
- 403 Index
- 413 List of Contributors