Paleobiology

(ISSN 0094-8373)

Volume 35

Number 3

Summer, 2009

CONTENTS

Matters of the Record	
Late Ordovician geographic patterns of extinction compared with simulations of astrophysical ionizing radiation damage Adrian L. Melott and Brian C. Thomas	311
Articles	
Biomechanics, functional patterns, and disparity in Late Devonian arthrodires Philip S. L. Anderson	321
The teeth of the "toothless": novelties and key innovations in the evolution of xenarthrans (Mammalia, Xenarthra)	
Sergio F. Vizcaíno	343
Foraminiferal diversification during the late Paleozoic ice age John R. Groves and Wang Yue	367
Stability of regional brachiopod diversity structure across the Mississippian/ Pennsylvanian boundary	
Noel A. Heim	393
Directional evolution in the conodont <i>Pterospathodus</i> David Jones	413
Estimating the effects of sampling biases on pterosaur diversity patterns: implications for hypotheses of bird/pterosaur competitive replacement	
Richard J. Butler, Paul M. Barrett, Stephen Nowbath, and Paul Upchurch Optimal estimators of the position of a mass extinction when recovery potential	432
is uniform Steve C. Wang, David J. Chudzicki, and Philip J. Everson	447
Tools for Paleobiology	
paleoPhylo: free software to draw paleobiological phylogenies Thomas H. G. Ezard and Andy Purvis	460

A quarterly journal of The Paleontological Society © 2009 The Paleontological Society. All rights reserved. Mailing Date: 13 July 2009 Electronic submission (PDF format) is requested: Paleo-Journal@si.edu

Or send manuscripts to:

Courier Address:

Department of Paileobiology, MRC 121 National Museum of Natural History 10th St. & Constitution Ave. NW Smithsonian Institution Washington, D.C. 20560-0121 Mailing Address:

Dept. of Paleobiology, MRC 121 National Museum of Natural History P.O. Box 37012 Smithsonian Institution Washington, D.C. 20013-7012

You can view and download *Paleobiology* from the world wide web in four places. Volumes 1–25 are at http://www.jstor.org. (PDF only; requires library subscription to ecology journals within JSTOR.) Current issues back to volume 26(1) are at http://www.bioone.org/ (with a library subscription to BioOne), and at http://www.psjournals.org. Titles and abstracts back to volume 22 are free at http://allenpress.com.

EDITORS:

MATTHEW T. CARRANO and PETER J. WAGNER

Smithsonian Institution

Matters of the Record

GENE HUNT

EDITOR:

Smithsonian Institution

COPYEDITOR:

NATASHA ATKINS

FOUNDING EDITORS:

THOMAS J. M. SCHOPF and RALPH G. JOHNSON

Address ALL matters regarding SUBSCRIPTIONS to:

Paleobiology Subscriptions

P.O. Box 1897 810 East 10th St.

Lawrence, KS 66044-8897

Paleobiology is published by the Paleontological Society. Members of the society automatically receive electronic subscriptions to *Paleobiology* and the *Journal of Paleontology* as a benefit of membership. 2009 membership fees are:

Regular individual members	\$50.00
Retired members	\$45.00
Student members	\$30.00
Spouses of members	\$25.00

Print subscriptions to *Paleobiology* are available to members of the Paleontological Society and the Palaeontological Association at the following rates, which are in addition to their membership fees:

Regular and Retired members	\$30.00
Student members	\$20.00

The 2009 institutional subscription rate for four issues of *Paleobiology* is \$200.00. Back issues: \$4.00 for members, \$16.00 for nonmembers. Price includes postage and handling.





PALEOBIOLOGY (ISSN 0094-8373) is published quarterly by The Paleontological Society, 810 East 10th St., Lawrence, KS 66044, USA. Periodicals postage paid at Lawrence, KS. POSTMASTER: Send address changes to PALEOBIOLOGY, P.O. Box 1897, 810 East 10th St., Lawrence, KS 66044-8897, USA.

PALEOBIOLOGY is printed offset by Allen Press, Inc., Lawrence, KS 66044.

The Paleontological Society gratefully acknowledges Patrons of *Paleobiology* for 2009.

The Patrons Fund was established to broaden the basis of financial support for *Paleobiology* and thus to encourage paleontological publication.

\$50.00 to \$100.00, at the discretion of the Contributor

For you, or your institution, to become a Patron, send a check payable to *Paleobiology* to:

Paleobiology Patrons Fund P.O. Box 1897 810 East 10th Street Lawrence, KS 66044-8897

PALEOBIOLOGY PATRONS

RICHARD P. ALVORD RICHARD K. BAMBACH MICHAEL G. BASSETT ANNA K. BEHRENSMEYER DAVID J. BOTTJER SANDRA J. CARLSON WILLIAM A. CLEMENS JR. AUREAL T. CROSS Paulo Custodi WILLIAM A. DIMICHELE JAMES O. FARLOW ROBERT M. FINKS KARL W. FLESSA MICHAEL J. FOOTE R. EWAN FORDYCE ROBERT A. GASTALDO IN MEMORY OF STEPHEN J. GOULD LEE M. GRAY JOHN C. HANDLEY CAROLE S. HICKMAN JOHN R. HORNER FREDERICK H. C. HOTCHKISS AUGUST ILG NINA JABLONSKI CHARLES KING MICHAL KOWALEWSKI MICHAEL LABARBERA WANN LANGSTON JR. DAVID R. LINDBERG JERE H. LIPPS ERNEST L. LUNDELIUS JR. Bruce I. MacFadden HARUYOSHI MAEDA NOBUO MAJIMA GEORGE R. McGHEE JR. Frank K. McKinney DAVID L. MEYER Arnold I. Miller WILLIAM C. MILLER III KEVIN PADIAN MARK E. PATZKOWSKY JARED P. PRICE Frederick J. Pugliese Bruce Runnegar W. BRUCE SAUNDERS IN MEMORY OF TOM SCHOPF CONSTANCE M. SOJA MARGARET S. STEVENS SHERMAN SUTER JOHN M. TATE ROGER D. K. THOMAS BRUCE H. TIFFNEY JAMES W. VALENTINE SALLY E. WALKER RON F. WASZCZAK JOHNNY A. WATERS PETER WILF