



# JOURNAL OF DAIRY SCIENCE<sup>®</sup> SINCE 1917

1800 S. Oak St., Ste 100, Champaign, IL 61820

Phone 217/356-5146 | Fax 217/378-4083 | [adsa@assoq.org](mailto:adsa@assoq.org) | <http://www.journalofdairyscience.org>

## EDITOR-IN-CHIEF

Roger D. Shanks (13)  
University of Illinois  
217/344-7512  
[rdshanks@illinois.edu](mailto:rdshanks@illinois.edu)

## DAIRY FOODS

Rafael Jimenez-Flores, Senior Editor (13)  
California Polytechnic State University  
[rjimenez@calpoly.edu](mailto:rjimenez@calpoly.edu)

Mary Anne Drake, Editor (14)  
North Carolina State University  
[m Drake@unity.ncsu.edu](mailto:m Drake@unity.ncsu.edu)

Stephanie Clark, Editor (13)  
Iowa State University  
[milkmade@iastate.edu](mailto:milkmade@iastate.edu)

## PHYSIOLOGY AND MANAGEMENT

Geoff Dahl, Senior Editor (13)  
University of Florida  
[gdahl@ufl.edu](mailto:gdahl@ufl.edu)

Rupert Bruckmaier, Editor (14)  
University of Bern  
[rupert.bruckmaier@physio.unibe.ch](mailto:rupert.bruckmaier@physio.unibe.ch)

Kerst Stelwagen, Editor (14)  
SciLactis  
[kerst.stelwagen@scilactis.co.nz](mailto:kerst.stelwagen@scilactis.co.nz)

Helga Sauerwein, Editor (14)  
University of Bonn  
[sauerwein@uni-bonn.de](mailto:sauerwein@uni-bonn.de)

David Beede, Editor (15)  
Michigan State University  
[beede@msu.edu](mailto:beede@msu.edu)

## NUTRITION, FEEDING, AND CALVES

John P. McNamara, Senior Editor (13)  
Washington State University  
[mcnamara@wsu.edu](mailto:mcnamara@wsu.edu)

Sergio Calsamiglia, Editor (13)  
Universidad Autonoma de Barcelona  
[sergio.calsamiglia@uab.es](mailto:sergio.calsamiglia@uab.es)

John Vicini, Editor (14)  
Monsanto Co.  
[john.L.vicini@monsanto.com](mailto:john.L.vicini@monsanto.com)

John Roche, Editor (15)  
Dairy NZ  
[john.roche@dairynz.co.nz](mailto:john.roche@dairynz.co.nz)

## GENETICS AND BREEDING

Georgios Banos, Senior Editor (14)  
Aristotle University of Thessaloniki  
[banos@vet.auth.gr](mailto:banos@vet.auth.gr)

Christa Kuhn, Editor (15)  
Res. Inst. Biol. Farm Anim.  
[kuehn@fbn-dummerstorf.de](mailto:kuehn@fbn-dummerstorf.de)

Jennie Pryce, Editor (14)  
Department of Primary Industries,  
Australia  
[jennie.pryce@dpi.vic.gov.au](mailto:jennie.pryce@dpi.vic.gov.au)

## INVITED REVIEWS

Filippo Miglior, Editor (15)  
Agriculture and Agri-Food Canada  
[miglior@cdn.ca](mailto:miglior@cdn.ca)

C. Dechow, Chair (13)  
Pennsylvania State University

Roger D. Shanks  
University of Illinois

D. McCoy, Board Liaison  
Dairy Research Inst.

R. M. Akers (15) VA (PM)  
H. G. Bateman II (13) OH (NFC)  
J. Blum (14) Switzerland (PM)  
B. Bradford (13) KS (NFC)  
W. Chen (14) China (DF)  
E. Connor (13) MD (PM)  
B. Corl (15) VA (PM)  
H. M. Dann (14) NY (NFC)  
T. Druet (14) Belgium (GB)  
T. Duong (13) TX (DF)  
L. Goddik (14) OR (DF)  
T. Gressley (13) DE (PM)  
M. Gunderson (13) IN (PM)  
H. Hammon (15) Germany (PM)  
F. Harte (15) TN (DF)

## President

R. K. McGuffey  
McGuffey Dairy Consulting

## Vice President

S. Rankin  
University of Wisconsin

## Treasurer

M. Schutz  
Purdue University

## Past President

R. F. Roberts  
The Pennsylvania State University

C. Luhman (13), Chair  
Land O'Lakes

M. Socha (13), Vice Chair  
Zinpro Corporation

M. Hanigan (13), Secretary  
Virginia Tech

Susan Pollock, Managing Editor  
Louise Adam  
Jorge Cazares  
Chris Davies

## JOURNAL MANAGEMENT COMMITTEE

P. Kononoff (14)  
University of Nebraska

R. M. Akers (15)  
Virginia Tech

M. J. Miller (16)  
University of Illinois

S. Pollock (ex officio)  
American Dairy Science Association

L. Adam (ex officio)  
American Dairy Science Association

P. Studney (ex officio)  
American Dairy Science Association

## EDITORIAL BOARD

A. Hassan (13) SD (DF)  
S. Hiss-Pesch (15) Germany (PM)  
J. Jamrozik (15) Canada (GB)  
D. Jones (12) IL (NFC)  
I. Kanevsky-Mullarky (15) VA (PM)  
A. F. Kertz (15) MO (NFC)  
H. Khatib (12) WI (GB)  
K. Krishnamurthy (14) IL (DF)  
J. Loor (13) IL (PM)  
J. Lucey (14) WI (DF)  
S. McDougall (12) New Zealand (PM)  
J. McKillip (15) IN (DF)  
E. Memili (14) MS (GB)  
L. Metzger (15) SD (DF)  
M. Miller (15) IL (DF)

K. Moyes (15) MD (PM)  
N. Odongo (13) Canada (NFC)  
K. O'Driscoll (13) England (PM)  
O. Østerås (13) Norway (PM)  
S. Pyörälä (13) Finland (PM)  
S. Rankin (12) WI (DF)  
P. Rezamand (14) ID (NFC)  
T. Schoenfuss (15) MN (DF)  
X. Sun (15) IN (GB)  
E. Titgemeyer (14) KS (NFC)  
R. L. Vallejo (13) WV (GB)  
E. Wall (14) VT (PM)  
W. Weiss (15) OH (NFC)  
T. Wright (13) Canada (NFC)

## ADSA OFFICERS

### Directors

D. McCoy (13)  
Dairy Research Inst.

R. Erdman (13)  
University of Maryland

S. Duncan (14)  
Virginia Tech

G. Dahl (14)  
University of Florida

L. Armentano (15)  
University of Wisconsin

R. Jimenez-Flores (15)  
Cal Poly State University

### Executive Director

P. Studney  
Champaign, IL

## ADSA FOUNDATION

M. Schutz (13), Treasurer  
Purdue University

Trustees:

D. McCoy (13)  
Dairy Research Inst.

S. Boucher (14)  
Hubbard Feeds

V. Mistry (14)  
South Dakota State University

K. Schmidt (15)  
Kansas State University

## FASS PUBLICATIONS STAFF

[journals@assoq.org](mailto:journals@assoq.org)

Sharon Frick  
Gayle Gleichman  
Armgard Haken  
Christine Horger

Ron Keller  
Lisa Krohn  
Shauna Miller



# JOURNAL OF DAIRY SCIENCE<sup>®</sup> SINCE 1917

1800 S. Oak St., Ste 100, Champaign, IL 61820

Phone 217/356-5146 | Fax 217/378-4083 | [adsa@assoqh.org](mailto:adsa@assoqh.org) | <http://www.journalofdairyscience.org>

**Postmaster:** Send address changes to *Journal of Dairy Science*, Elsevier Health Sciences Division, Subscription Customer Service, 3251 Riverport Lane, Maryland Heights, MO 63043.

**Customer Service (orders, claims, back volumes, online access, change of address):** Elsevier Health Sciences Division, Subscription Customer Service, 3251 Riverport Lane, Maryland Heights, MO 63043. Telephone: 800.654.2452 (US and Canada), 314.447.8871 (outside US and Canada); fax: 314.447.8029; e-mail: [journalscustomerservice-usa@elsevier.com](mailto:journalscustomerservice-usa@elsevier.com) (for print support) or [journalsonlinesupport-usa@elsevier.com](mailto:journalsonlinesupport-usa@elsevier.com) (for online support). Allow 4 to 6 weeks for the change of address to be implemented.

**Institutional Subscription Rates:** For institutions in the United States and possessions: \$879 for print. For institutions in all other countries (prices include airspeed delivery): \$991 for print. Current prices are in effect for back volumes and back issues. Electronic access is additional. Please contact customer service for pricing.

**ADSA Membership Rates:** For individual membership, contact the ADSA office ([adsa@assoqh.org](mailto:adsa@assoqh.org)) to pay dues and obtain access to the journal. For professional members: \$110 per year, graduate student membership: \$10, undergraduate student affiliate membership: \$5. Membership includes electronic version of the journal; additional \$56 for paper copy in US, and additional \$83 for paper copy in all other countries). Membership in the ADSA is on a calendar year basis from January through December.

**Advertising Information:** To advertise a position announcement in the News and Announcements section of the journal, please use the FASS Job Resource Center (<http://www.fass.org/job.asp>); e-mail [jrc@assoqh.org](mailto:jrc@assoqh.org) if you have questions.

For display advertising orders and inquiries please contact Ken Senerth at 609.577.0916; by fax at 212.633.3980; or by e-mail at [kensenerth@gmail.com](mailto:kensenerth@gmail.com). For non-recruitment classified advertising orders and inquiries please contact John Marmero at 212.633.3657; by fax at 212.633.3820; or by e-mail at [j.marmero@elsevier.com](mailto:j.marmero@elsevier.com).

**Author Inquiries:** For inquiries relating to the submission of articles, complete Instructions for Authors can be found online at <http://www.journalofdairyscience.org>. Manuscripts submitted for consideration should be submitted electronically at <http://mc.manuscriptcentral.com/jds> in accordance with the Instructions for Authors. Need help? Contact [shaunam@assoqh.org](mailto:shaunam@assoqh.org).

**Offprints.** Authors may place orders for offprints when proof corrections are sent to the editorial office (before the journal is sent for printing). For queries about offprints or order status, e-mail [vickip@assoqh.org](mailto:vickip@assoqh.org); fax 217.378.4083.

**Reprints.** To order author reprints after the issue has been printed, e-mail [authorsupport@elsevier.com](mailto:authorsupport@elsevier.com). To order 100 or more reprints for educational, commercial, or promotional use, contact the Commercial Reprints Department, Elsevier Inc., 360 Park Avenue South, New York, NY 10010-1710; fax: 212.633.3820; e-mail: [reprints@elsevier.com](mailto:reprints@elsevier.com). Access to single articles available online may be obtained by purchasing Pay-Per-View access on the journal website (<http://www.journalofdairyscience.org>).

© 2013 American Dairy Science Association<sup>®</sup>. All rights reserved.

This journal and the individual contributions contained in it are protected under copyright by the American Dairy Science Association and the following terms and conditions apply to their use:

**Photocopying:** Single photocopies of single articles may be made for personal use as allowed by national copyright laws. Permission of the Publisher and payment of a fee is required for all other photocopying, including multiple or systematic copying, copying for advertising or promotional purposes, resale, and all forms of document delivery. Special rates are available for educational institutions that wish to make photocopies for non-profit educational classroom use. Permissions may be sought directly from Elsevier's Rights Department in Oxford, UK. Telephone: 215.238.7869 or +44 (0) 1865 843830; fax: +44 (0) 1865 853333; e-mail: [permissions@elsevier.com](mailto:permissions@elsevier.com). Requests may also be completed online via the Elsevier homepage (<http://www.elsevier.com/locate/permissions>).

In the United States, users may clear permissions and make payments through the Copyright Clearance Center Inc., 222 Rosewood Drive, Danvers, MA 01923. Telephone: 978.750.8400; fax: 978.750.4744; and in the UK through the Copyright Licensing Agency Rapid Clearance Service (CLARCS), 90 Tottenham Court Road, London W1P 0LP, UK. Telephone: +44 20 7631 5555; fax: (+44) 20 7631 5500. Other countries may have a local reprographic rights agency for payments.

**Derivative Works:** Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution. Permission of the Association and Publisher is required for all other derivative works, including compilations and translations.

**Electronic Storage or Usage:** Permission of the Publisher is required to store or use electronically any material contained in this journal, including any article or part of an article.

Except as outlined above, no part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of the Publisher.

Address permissions requests to Elsevier Rights Department at the fax and e-mail addresses noted above.

**Notice:** No responsibility is assumed by the Association, the Federation of Animal Science Societies, or the Publisher for any injury and/or damage to persons or property as a matter of product liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made.

Mention of any trademark or proprietary product in works published in the *Journal of Dairy Science* does not constitute a guarantee or warranty of the product by the American Dairy Science Association and does not imply its approval to the exclusion of other products that may also be suitable.

Although all advertising material is expected to conform to ethical (medical) standards, inclusion in this publication does not constitute a guarantee or endorsement of the quality or value of such product or of the claims made of it by its manufacturer.