

Part III

Comparative Nutrition

4

Animal Needs and Uses (Comparative Nutrition)

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Overview — Nutritional Requirements for Different Species

The nutritional requirements for different species of animals, including mammals, birds and fish, vary markedly. Many factors influence the requirements for specific nutrients. Within species, some of the factors affecting nutritional requirements are age, gender, stage of maturity, level of activity (work), body size, type and level of production (i.e. lean or adipose body tissue, milk, eggs, wool, bone growth, etc.), environment, physiological function (i.e. maintenance, pregnancy, lactation), health, and endocrinological factors. Between and among species, the type of gastrointestinal tract greatly influences the nutritional requirements of the animal, and the type of food it may eat to provide the nutrients. For example, ruminants (cattle, sheep, goats, and deer), as a result of microbial fermentation in the upper gastrointestinal tract, have quite different nutritional requirements than nonruminants (humans, swine, dogs, cats, non-human primates). Ruminants, and other herbivores that have extensive microbial fermentation in the large intestine and cecum, may utilize cellulose, hemicellulose, and other high fiber diets that nonruminants cannot digest. This adaptation also results in differences in the requirements for dietary sources of some of the B vitamins and amino acids.

Some species store bile from the liver in the gallbladder (humans, swine, cattle, sheep, chickens), whereas others (rats, horses, deer, elk, moose, camels) have no reservoir to store bile, and this in turn may affect lipid digestion. Another species difference is in nitrogen utilization. For example, mammals excrete excess nitrogen resulting from protein metabolism as urea, whereas birds excrete uric acid. Many different species of animals have been used extensively as research models to obtain data on the nutrient requirements of humans, and to learn the mode of action of various dietary additives. The researcher must be aware of differences in the nutritional requirements of different species, or erroneous conclusions could be drawn. For example, vitamin C is required for humans, guinea pigs, and monkeys but not for swine and rats, which are frequently used as animal models.

It is essential for livestock, poultry, and aquatic food producers as well as veterinarians, animal caretakers, biomedical research scientists, and others involved in caring for and feeding animals to know what nutrients are required and the amounts of each, the effects of different factors on the efficiency of nutrient utilization, and how best to provide feeds

with the proper proportions of these nutrients to the animals. Because of the economic importance of this knowledge, scientists throughout the world have conducted research with different species of animals, birds, and fish, and feeding standards based on this research have been developed to formulate diets and rations for domestic livestock, poultry, companion animals, laboratory animals, and other species.

During the past century, scientists from many nations have conducted research on the specific nutritional requirements of numerous species of animals, but there are so many interactions among nutrients — and so many factors that influence nutrient utilization by different species — that tables or formulae for calculating nutritional requirements must be modified periodically. The data presented in this section are based on research summarized by groups of scientists who are most knowledgeable about the nutritional research that has been conducted anywhere in the world on that particular species. In the United States, the National Academy of Sciences, National Research Council (NRC), Board on Agriculture, Committee on Animal Nutrition has been responsible for appointing committees of expert animal scientists to publish periodical reports that summarize the most up-to-date information on nutritional requirements of various species. The nutrient composition of feeds usually consumed by these animals is also included in each of the publications, because the feed evaluation system used to express the nutritional value of feeds determines the manner in which the nutritional requirements of the animal are expressed. Specific information on each species may be obtained by obtaining the most recent NRC publication on that species.

The health and wellbeing of animals are affected markedly by their nutritional status. It is important to know how to properly provide feed that contains the nutrients animals need to meet their nutritional requirements. This applies to companion animals such as dogs, cats, birds, and fish as well as recreational animals such as horses, ponies, donkeys, and camels. The efficient and economical production of food and fiber by domestic livestock and poultry requires good management practices, and especially balanced rations that contain adequate supplies of protein, minerals, vitamins, and energy. In most, if not all, animal production systems a limited energy supply more frequently retards growth and limits production than a deficiency of any other nutrient. Crampton (1956)¹ stated that “the basic need of animals fed normal rations is for energy, and this demand is the basis for most, and perhaps all, of the other nutrient requirements.”

The National Research Council, Board on Agriculture, Committee on Animal Nutrition subcommittees prepare reports periodically published by the National Academy Press, 2101 Constitution Avenue NW, Washington, D.C. 20055. The most recent publications (dairy cattle, horses, beef cattle, and swine) have included computer disks with tables of nutrient requirements and feed composition. The full text, including tables, for *Nutrient Requirements of Swine*, 10th Revised Edition, 1998, and may be accessed on the web site of the National Academy Press (<http://books.nap.edu>).

The most recent National Academy Press series of publications on Nutrient Requirements of Domestic Animals is summarized in Table 4.1. The pages of the tables of nutrient requirements of each species are included, but in order to use this information most effectively, the tables of nutrient composition of most commonly used feed ingredients are needed. The feed composition tables are included in each of these publications. The 1999 *Feedstuffs* Reference Issue (Volume 71, Number 31, July 30, 1999, pages 40-84) has tables based on the NRC publications for swine, beef cattle, dairy cattle, chickens and turkeys, horses, and pets (dogs and cats). There are numerous publications, including animal nutrition textbooks, that have used the tables of nutrient requirements of various species of livestock as well as the tables of nutrient composition. One recent example is *Livestock Feeds and Feeding, 4th Edition*, 1998, by Richard O. Kellems and D.C. Church, Prentice Hall, New Jersey. The species included in this text are: beef cattle, dairy cattle,

sheep, goats, swine, poultry, horses, dogs and cats, and rabbits (pages 485–552). Tables of the composition of feedstuffs commonly fed to livestock are on pages 468–484.

Sources of Information for the Nutrient Requirements of Various Species

Nutrient Requirements of Domestic Animals: A Series. Subcommittees of the Committee on Animal Nutrition, Board on Agriculture, National Research Council. National Academy Press. Washington, D.C.

Publications with details, including complete text of most of the current publications are on the computer web site (URL) at <http://books.nap.edu>. To locate each publication type “Nutrient Requirements” in the box labeled SEARCH ALL TITLES. Tables with specific information on the nutrient requirements of each species as well as the composition of diet ingredients (feedstuffs) may be accessed by clicking on OPEN BOOK Searchable READ.

Companion Animals (Cats and Dogs)

Cats

Nutrient Requirements of Cats, Revised Edition, 1986, 88 pp. 8.5 X 11, 1986 ISBN 0-309-03682-8 (SF 447.6 .N88 1986).

Subcommittee on Cat Nutrition

Quinton R. Rogers, Chairman, University of California, Davis

David H. Baker, University of Illinois

Kenneth C. Hayes, Brandeis University

Peter T. Kendall, Pedigree Foods

James C. Morris, University of California, Davis

Dogs

Nutrient Requirements of Dogs, Revised 1985, 79 pp. ISBN 0-309-03496-5 (S 95 .N28 1985).

Subcommittee on Dog Nutrition

Ben E. Sheffy, Chairman, Cornell University

Kenneth C. Hayes, Brandeis University

Joseph J. Knapka, National Institutes of Health

John A. Milner, University of Illinois at Urbana-Champaign

James G. Morris, University of California, Davis

Dale R. Romsos, Michigan State University

Mink and Foxes

Nutrient Requirements of Mink and Foxes, Second Revised Edition, 1982 (BOA) 72 pp. ISBN 0-309-03325-X.

Subcommittee on Furbearer Nutrition, 1982
Hugh Travis, Chairman, USDA, SEA, Cornell University
E.V. Evans, University of Guelph, Ontario
Gunnar Joergensen, National Institute of Animal Science, Denmark
Richard J. Aulerich, Michigan State University
William L. Leoschke, Valparaiso University, Indiana
James E. Oldfield, Oregon State University

Rabbits

Nutrient Requirements of Rabbits, Second Revised Edition, 1977.

Subcommittee on Rabbit Nutrition, 1977
Arrington Lewis, Chairman
Peter R. Cheeke
Francois Lebas
Sedgwick E. Smith, Cornell University

Laboratory Animals

Rat, mouse, guinea pigs, hamster, gerbils, voles

Nutrient Requirements of Laboratory Animals, Fourth Revised Edition, 1995 (BOA),
Nutrient Requirements of Domestic Animals, National Research Council, National Academy Press, Washington, D.C. 1995. 173 pp. ISBN 0-309-05126-6 (SF 406.2 .N88 1995).

Subcommittee on Laboratory Animal Nutrition
Norlin J. Benevenga, Chair, University of Wisconsin, Madison
Christopher Calvert, University of California, Davis
Curtis D. Eckhert, University of California, Los Angeles
Janet L. Greger, University of Wisconsin, Madison
Carl L. Keen, University of California, Davis
Joseph J. Knapka, National Institutes of Health, Bethesda, Maryland
Hulda Magalhaes, Bucknell University
Olav T. Oftedal, National Zoological Park, Washington, D.C.
Philip G. Reeves, Agricultural Research Service, U.S. Department of Agriculture, Grand Forks, North Dakota
Helen Anderson Shaw, University of North Carolina, Greensboro
John Edgar Smith, Pennsylvania State University, University Park
Robert D. Steele, University of Wisconsin

Fish

Nutrient Requirements of Fish (BOA) 128 pp., ISBN-04891-5, 1993 (SH 156 .N86 1993).

Subcommittee on Fish Nutrition

Richard T. Lovell, Chair, Auburn University

C. Young Cho, University of Guelph and Fisheries Branch, Ontario

Ministry of Natural Resources, Canada

Colin B. Cowey, University of Guelph, Canada

Konrad Dabrowski, The Ohio State University

Steven Hughes, U.S. Fish and Wildlife Service, Monell Chemical

Senses Center, Philadelphia, Pennsylvania

Santosh Lall, Nova Scotia Department of Fisheries and Ocean, Canada

Takeshi Murai, National Institute of Fisheries Science, Tokyo, Japan

Robert P. Wilson, Mississippi State University

Avian Species

Poultry (chickens, turkeys, geese, ducks, pheasants, Japanese quail, bobwhite quail)

Nutrient Requirements of Poultry, Ninth Revised Edition, 1994 (BOA) 176 pp., ISBN 0-309-04892-3.

Subcommittee on Poultry Nutrition

Jerry L. Sell, Chair, Iowa State University

F. Howard Kratzer, University of California, Davis

J. David Latshaw, The Ohio State University

Steven L. Leeson, University of Guelph

Edwin T. Moran, Auburn University

Carl M. Parsons, University of Illinois

Park W. Waldroup, University of Arkansas

Domestic Livestock

Nonruminant Species

Swine

Nutrient Requirements of Swine, Tenth Revised Edition, 1998 (BOA) 210 pp., ISBN 0-309-05993-3, Computer laser optical disc (4 3/4 in.).

Subcommittee on Swine Nutrition

Gary L. Cromwell, Chair, University of Kentucky

David H. Baker, University of Illinois

Richard C. Ewan, Iowa State University

E.T. Kornegay, Virginia Polytechnic Institute and State University

Austin J. Lewis, University of Nebraska

James E. Pettigrew, Pettigrew Consulting International, Louisiana, Missouri

Norman C. Steele, U.S.D.A., A.R.S., Beltsville, Maryland

Philip A. Thacker, University of Saskatchewan, Canada

Horses

Nutrient Requirements of Horses, Fifth Revised Edition, 1989 (BOA) 112 pp., ISBN 03989-4.

Subcommittee on Horse Nutrition

Edgar, A. Ott, Chairman, University of Florida, Gainesville

John P. Baker, University of Kentucky

Harold F. Hintz, Cornell University

Gary D. Potter, Texas A & M University

Howard D. Stowe, Michigan State University

Duane E. Ullrey, Michigan State University

Ruminant Species

Beef cattle

Nutrient Requirements of Beef Cattle, Seventh Revised Edition, 1996 (BOA) Note: The 7th Revised Edition Update 2000 was released and is on the web site. 242 pp., ISBN 0-309-05426-5, 1 computer disk (3 1/2 in.).

Subcommittee on Beef Cattle Nutrition, 1996

Jock G. Buchanan-Smith, Chair, University of Guelph, Canada

Larry L. Berger, University of Illinois

Calvin L. Ferrell, U.S.D.A., A.R.S., Clay Center, Nebraska

Danny G. Fox, Cornell University

Michael L. Galyean, Clayton Livestock Research Center, Clayton, New Mexico

David P. Hutcheson, Animal Agricultural Consulting, Inc., Amarillo, Texas

Terry J. Klopfenstein, University of Nebraska

Jerry W. Spears, North Carolina State University

Dairy cattle

Nutrient Requirements of Dairy Cattle, Sixth Revised Edition, Update 1989 (BOA) 168 pp., ISBN 0-309-03826-X.

Subcommittee on Dairy Cattle Nutrition

Roger W. Hemken, Chairman, University of Kentucky

Clarence B. Ammerman, University of Florida

Donald L. Bath, University of California, Davis

Jimmy H. Clark, University of Illinois

Neal A. Jorgensen, University of Wisconsin

Paul W. Moe, U.S. Department of Agriculture, Beltsville, Maryland

Lawrence D. Muller, Pennsylvania State University

Dale R. Waldo, U.S. Department of Agriculture, Beltsville, Maryland

Sheep

Nutrient Requirements of Sheep, Sixth Revised Edition, 1985 (BOA) 112 pp., ISBN 0-309-03596-1.

Subcommittee on Sheep Nutrition

Robert M. Jordan, Chairman, University of Minnesota

Millard C. Calhoun, Texas Agricultural Experiment Station, San Angelo

Donald G. Ely, University of Kentucky

David P. Heaney, Research Branch, Agriculture Canada, Ottawa

Frank C. Hinds, University of Wyoming

Donald E. Johnson, Colorado State University

Goats

Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries (BOA) 84 pp., ISBN 0-309-03185-0 (SF 95. N28 no. 15).

Subcommittee on Goat Nutrition

George F.W. Haenlein, Chairman, University of Delaware, Newark

Canagasaby Devendra, Maylasian Agricultural Research and Development Institute, Serdang, Maylasia

James E. Huston, Texas A&M University, San Angelo

O.P.S. Sengar, Raja Balwant Singh College, Bichpuri (Agra), India

Maurice Shelton, Texas A&M University, San Angelo

S.N. Singh, Raja Balwant Singh College, Bichpuri (Agra), India

Nonhuman Primates

Nutrient Requirements of Nonhuman Primates 1978 ix, 83 p.: ill. :28 cm. 1978 ISBN 0-309-02786-1 (SF 95 .N28 1978).

Panel on Nonhuman Primates

George R. Kerr, Chairman, University of Texas School of Public Health

Coy D. Fitch, St. Louis University

Ronald D. Hunt, New England Regional Primate Center

Nutrient Requirement Table 1 pages 18-19.

Nutrient Requirements of Nonhuman Primates: Second Revised Edition, 2000, 300 pages (not yet available).

TABLE 4.1**Web Addresses for Tables of Nutrient Requirements for a Variety of Animals**

National Academy Press. Washington, D.C. List of publications with tables of nutrient requirements of each species. <http://books.nap.edu>. To obtain complete text, including tables, fill in the box labeled SEARCH ALL TITLES with "Nutrient Requirements" and all the following publications with hyperlinks will appear at URL <http://books.nap.edu/catalog/910.html>.

Nutrient Requirements of Cats, Revised Edition, 1986 (SF 447.6 .N88 1986) Nutrient Requirement Tables, pages 41-44. (<http://www.nap.edu/openbook/0309036828/html>)

Nutrient Requirements of Dogs, Revised 1985 (S 95 .N28 1985) Nutrient Requirement Tables, pages 44-45. (<http://www.nap.edu/openbook/0309034965/html/44.html>)

Nutrient Requirements of Mink and Foxes, Second Revised Edition, 1982 (SF 95 .N28 1982) Nutrient Requirement Tables, pages 33-36. (<http://www.nap.edu/openbook/030903325X/html/33.html>)

Nutrient Requirements of Rabbits, Second Revised Edition, 1977 (SF 95 .N32 1977) Nutrient Requirement Tables, pages 14-15. (<http://www.nap.edu/openbook/0309026075/html/14.html>)

Nutrient Requirements of Laboratory Animals, Fourth Revised Edition, 1995 (SF 406.2 .N88 1995) Nutrient Requirement Tables for Rats, page 13; Mice, page 82; Guinea Pigs, page 104-105; (Hamsters, Gerbils, and Voles — text rather than tables) (<http://www.nap.edu/openbook/0309051266/html/11.html>)

Nutrient Requirements of Fish, 1993 (SH 156 .N86 1993) Nutrient Requirements Table, pages 62-63. (<http://www.nap.edu/openbook/0309048915/html/62.html>)

Nutrient Requirements of Poultry, Ninth Revised Edition, 1994 (SF 95 .N28 1994) Nutrient Requirement Tables for Chickens, pages 19-34 for Tables 2-1 through 2-8; for Turkeys, pages 35-39, Tables 3-1 through 3-3; for Geese pages 40-41; for Ducks, pages 42-43; for Ring-Necked Pheasants, page 44; for Japanese Quail, page 45; for Bobwhite Quail, page 45. (<http://www.nap.edu/openbook/0309048923/html/19.html>)

Nutrient Requirements of Swine, 10th Revised Edition, 1998 (SF 396.5 .N87 1998). Nutrient Requirement Tables, pages 110-123. Computer laser optical disc (4 3/4 in.). (<http://www.nap.edu/openbook/0309059933/html/110.html>)

Nutrient Requirements of Horses, Fifth Revised Edition, 1989 (SF 285.5 .N37 1989). Nutrient Requirement Tables, pages 39-48. Computer disk (5 1/4 in.). (<http://www.nap.edu/openbook/0309039894/html/39.html>)

Nutrient Requirements of Beef Cattle, Seventh Revised Edition, 1996 (SF 203 .N88 1996) Nutrient Requirement Tables, pages 102-112. Prediction Equations and Computer Models, pages 113-131. Computer disk (3 1/2 in.). (<http://www.nap.edu/openbook/0309069343/html/102.html>)

Nutrient Requirements of Beef Cattle, Seventh Revised Edition: Update 2000, NRC Model Application software available on line at <http://stills.nap.edu/readingroom/books/beefmodel/>

Nutrient Requirements of Dairy Cattle, Sixth Revised Edition, Update 1989 (SF 203 .N34 1988) Nutrient Requirement Tables, pages 78-88. Computer disk (5 1/4 in.). (<http://www.nap.edu/openbook/030903826X/html/78.html>)

Nutrient Requirements of Sheep, Sixth Revised Edition, 1985 (SF 376 .N85 1985) Nutrient Requirement Tables, pages 45-53. (<http://www.nap.edu/openbook/0309035961/html/45.html>)

Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries, 1981 (S 95 .N28 1981) Nutrient Requirement Tables, pages 10-12. (<http://www.nap.edu/openbook/0309031850/html/10.html>)

Nutrient Requirements of Nonhuman Primates 1978 (SF 95 .N28 1978) Nutrient Requirement Table 1 pages 18-19. Print-On-Demand. (<http://books.nap.edu/catalog/34.html>)

Nutrient Requirements of Nonhuman Primates: Second Revised Edition, 2000 300 pages In press, not yet available.

TABLE 4.2

Publications Providing Information on the Nutrient Needs of Specific Animals

A. Nutrient requirements of companion animals (cats and dogs), rabbits, mink and foxes, and laboratory animals (rats, mice, guinea pigs, hamsters, gerbils, and voles) and rabbits, mink, and foxes. Tables of nutrient requirements from *Nutrient Requirements of Domestic Animals: A Series*. National Research Council, National Academy Press (<http://books.nap.edu>)

Species	NRC Publication	Year last revised	Pages of Tables	Computer disk	NAP Web site of Tables
<i>Companion Animals</i>					
Cats	<i>Nutrient Requirements of Cats</i>	1986	41–44	No	Yes
Dogs	<i>Nutrient Requirements of Dogs</i>	1985	44–45	No	Yes
<i>Laboratory Animals</i>					
	<i>Nutrient Requirements of Laboratory Animals</i>	1995	13–105	No	Yes
Rats	<i>Nutrient Requirements of Laboratory Animals</i>	1995	13	No	Yes
Mice	<i>Nutrient Requirements of Laboratory Animals</i>		82	No	Yes
Guinea pigs	<i>Nutrient Requirements of Laboratory Animals</i>		104–105	No	Yes
Hamsters	<i>Nutrient Requirements of Laboratory Animals</i>		Text	No	Yes
Gerbils	<i>Nutrient Requirements of Laboratory Animals</i>		Text	No	Yes
Voles	<i>Nutrient Requirements of Laboratory Animals</i>		Text	No	Yes
<i>Other Small Animals</i>					
Rabbits	<i>Nutrient Requirements of Rabbits</i>	1977	14–15	No	Yes
Mink	<i>Nutrient Requirements of Mink and Foxes</i>	1982	33–34	No	Yes
Foxes	<i>Nutrient Requirements of Mink and Foxes</i>	1982	35–36	No	Yes

B. Nutrient requirements of poultry (chickens, turkeys, geese, ducks, ring-necked pheasants, Japanese quail and bobwhite quail), fish, nonhuman primates, horses and swine. Tables of nutrient requirements from *Nutrient Requirements of Domestic Animals: A Series*. National Research Council, National Academy Press (<http://books.nap.edu>)

Species	NRC Publication	Year last revised	Pages of Tables	Computer disk	NAP Web site of Tables
<i>Avian Species</i>					
	<i>Nutrient Requirements of Poultry</i>	1994	19–45	No	Yes
Chickens	<i>Nutrient Requirements of Poultry</i>	1994	19–34	No	Yes
Turkeys	<i>Nutrient Requirements of Poultry</i>	1994	35–39	No	Yes
Geese	<i>Nutrient Requirements of Poultry</i>	1994	40–41	No	Yes
Ducks	<i>Nutrient Requirements of Poultry</i>	1994	42–43	No	Yes
Ring-necked pheasants	<i>Nutrient Requirements of Poultry</i>	1994	44	No	Yes
Japanese quail	<i>Nutrient Requirements of Poultry</i>	1994	45	No	Yes
Bobwhite quail	<i>Nutrient Requirements of Poultry</i>	1994	45	No	Yes

B. Nutrient requirements of poultry (chickens, turkeys, geese, ducks, ring-necked pheasants, Japanese quail and bobwhite quail), fish, nonhuman primates, horses and swine. Tables of nutrient requirements from *Nutrient Requirements of Domestic Animals: A Series*. National Research Council, National Academy Press (<http://books.nap.edu>)

Species	NRC Publication	Year last revised	Pages of Tables	Computer disk	NAP Web site of Tables
<i>Other Species</i>					
Fish	<i>Nutrient Requirements of Fish</i>	1993	62–63	No	Yes
Nonhuman Primates	<i>Nutrient Requirements of Nonhuman Primates</i>	1978 (2000 in press)	18–19	No	No (Yes, soon for 2000)
Horses	<i>Nutrient Requirements of Horses</i>	1989	39–48	Yes (5 1/4 in.)	Yes
Swine	<i>Nutrient Requirements of Swine</i>	1998	110–123	Yes (Laser optical disk, 4 3/4 in.)	Yes

C. Nutrient requirements of ruminants (beef cattle, dairy cattle, sheep and goats). Tables of nutrient requirements from *Nutrient Requirements of Domestic Animals: A Series*. National Research Council, National Academy Press (<http://books.nap.edu>)

Species	NRC Publication	Year last revised	Pages of Tables	Computer disk	NAP Web site of Tables
<i>Ruminant Species</i>					
Beef Cattle	<i>Nutrient Requirements of Beef Cattle</i>	2000	102–112	Yes (3 1/2 in.)	Yes
Dairy Cattle	<i>Nutrient Requirements of Dairy Cattle</i>	1989	78–88	Yes (5 1/4 in.)	Yes
Sheep	<i>Nutrient Requirements of Sheep</i>	1985	45–53	No	Yes
Goats	<i>Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries</i>	1981	10–12	No	Yes

References

1. Crampton, EW. 1956. *Applied Animal Nutrition. The Use of Feedstuffs in the Formulation of Livestock Rations*. W.H. Freeman and Co., San Francisco, CA.