

Future Directions in Zoological Medical Education: Expectations, Potential, Opportunities, and Mandates

The Future of Training for Aquatic Animal Health Veterinarians

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ABSTRACT

This article describes educational approaches for training veterinary students, veterinary graduates, and practicing veterinarians in the area of aquatic animal health and lists a range of general research, training, internship/residency, and continuing-education resources.

INTRODUCTION

While aquaculture is a centuries-old method of farming that is practiced throughout the world, veterinary involvement in aquaculture and aquatic animal medicine is a relatively recent development. As aquaculture products make up an increasing and significant part of our seafood, ornamental, and pet industries, the need for sound veterinary input will continue to grow. In addition to an increase in the volume and monetary value of aquaculture products, the variety and number of aquatic species that are now commercially raised has also been increasing.

In the United States, several veterinary schools offer courses in aquatic animal medicine, including courses or learning experiences focused on aquaculture and aquatic animal health; currently, however, most veterinary students and veterinarians receive their aquatic animal medicine training through extracurricular programs and independent study. While we realize that there is little room in most veterinary curricula for expansion, including at least some introductory course- and laboratory work related to aquatic animal medicine could be of great benefit to veterinary students. Pertinent topics would include aquaculture of invertebrates and finfish, clinical management of captive fishes, clinical management of aquatic reptiles, and clinical management of captive marine mammals. Even if these topics could not be included in the core curriculum, a one- or two-credit elective course could meet these needs and serve as a foundation for future academic pursuits (even post-DVM).

The keeping of fish as pets is a hobby with a long history. In recent years, particularly during the past decade, ornamental pond fish, including koi and goldfish, have become increasingly popular in various parts of the world, including the United States. In fact, more fish are kept as pets in the United States than any other single group of animals, including dogs, cats, small mammals, birds, and reptiles.⁶ The pet fish hobby has also become more sophisticated in recent years, and growing numbers of veterinarians are gaining clinical experience with pet fish as well as incorporating pet fish medicine into their clinical practice.²⁻⁶ Prior to 1980, except in rare instances, most

medical care and husbandry practices for pet fish were performed by the hobbyists themselves, or with assistance from a local pet-store clerk or aquarium maintenance person. Many of these lay people are very knowledgeable and conscientious, but there are no minimum training standards for their vocation, as there are in the veterinary profession. Veterinarians are taught the principles of medicine, surgery, and animal husbandry. Furthermore, the same fundamental disciplines, such as critical care, microbiology, parasitology, nutrition, pathology, and surgery, that are applied to terrestrial animals may also be applied to aquatic animals.

In addition to private practitioners expanding their practices to include fish and other aquatic animals, the job market for industry and institutional aquatic animal veterinarians has expanded greatly over the past decade or so. Most major public aquariums have at least one staff veterinarian, and many have several, including interns and residency trainees. Even the smallest aquariums have a part-time veterinarian or a consulting arrangement with a veterinarian or university. Many zoos, which employ hundreds of veterinarians in the United States, now have extensive aquatic animal exhibits, and zoo veterinarians commonly treat fishes, aquatic reptiles, aquatic birds, and aquatic mammals. As the aquaculture industry has expanded, opportunities for veterinarians, including aquatic animal pathologists, have increased. Veterinarians now play key roles in state and federal governmental agencies, including, but not limited to, the National Marine Fisheries Service (NMFS), the US Department of Agriculture (USDA), the US Food and Drug Administration (FDA), the US Fish and Wildlife Service (USFWS), and the US Geological Survey (USGS). Aquatic animals, especially invertebrate and fish species, are becoming increasingly important laboratory animals. This is an area of substantial growth, and there is, and will likely continue to be, a need for experienced aquatic animal practitioners and researchers.

It is anticipated that the job market for aquatic animal veterinarians will continue to expand, especially as international commerce in aquatic animals continues, public aquariums continue their rise in popularity, aquaculture and appropriate bio-security measures become more

sophisticated, aquatic animals gain importance as laboratory research models, and conservation efforts on behalf of threatened and endangered aquatic species expand in both scope and focus.

As our knowledge of aquatic animal diseases and therapeutics increases, more and more veterinarians will be trained and qualified to work responsibly with these animals. Peer-reviewed articles on the clinical management of aquatic species case problems now appear in many veterinary journals. Nearly every major veterinary conference includes aquatic animal medicine in its program, and several veterinary schools now offer continuing education (CE) courses on this subject. In addition, many textbooks and review articles contain valuable information on pet fish medicine. The appendices to this article provide an array of resources now available for aquatic veterinary education: Continuing Education Opportunities in Aquatic Animal Medicine (Appendix A), Available Internships and Residencies (Appendix B), General References for Different Areas of Aquatic Animal Medicine (Appendix C), Aquatic Animal Health/Medicine Journals (Appendix D), and some other useful Aquatic Medicine Resources (Appendix E).

NOTE

- a Portions of this article contain modified text previously published in the 2005 *Proceedings of the North American Veterinary Conference* and the *American Veterinary Medical Association Convention*, which was based on content presented at the Expanding Private Practitioner Opportunities in Fish Medicine 2004 pre-conference session of the International Association for Aquatic Animal Medicine.

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- 3 Lewbart GA. Pet fish medicine beckons to pioneer veterinarians. *Vet Product News* 11(3):50–51, 1999.
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- 5 Smith CA. Pet fish medicine offers new challenges. *J Am Vet Med Assoc* 205:1267–1271, 1994.
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APPENDIX A: CONTINUING EDUCATION OPPORTUNITIES IN AQUATIC ANIMAL MEDICINE

Aquatic Animal Health Continuing Education Programs

Formal CE courses are typically organized through an academic institution. Courses vary in costs and length as well as in topic emphasis. Not all the courses listed below have been approved for official CE credit, so please refer to the specific course site for complete information.

Cornell University: <<http://www.vet.cornell.edu/Public/FishDisease/AquaticProg/ceo.htm>>

University of Florida: <<http://conference.ifas.ufl.edu/ame/>>

North Carolina State University: <<http://www.cvm.ncsu.edu/conted/fish/>>

AQUAVET, Woods Hole, MA (University of Pennsylvania/Cornell University) (AQUAVET I~4 weeks; AQUAVET II~2 weeks): <<http://web.vet.cornell.edu/public/aquavet/index.htm>>

AQUAMED, Baton Rouge, LA (Gulf States Consortium, CsVM) (~4 weeks): <<http://www.vetmed.lsu.edu/aquamed.htm>>

Envirovet (University of Illinois, Urbana-Champaign, CVM) (~6 weeks): <<http://www.cvm.uiuc.edu/envirovet/>>

Internet-Based Continuing Education

The Internet has become an important communication and educational tool. The Veterinary Information Network (VIN) offers several online opportunities for CE in aquatic animal medicine. There are two courses on fish medicine, one in basic fish medicine <<http://www.vin.com/ce/EXOT200-0304.htm>>, and another at the intermediate level, which began in spring 2006 <<http://www.vin.com/ce/EXOT201-0306.htm>>. These courses are offered in alternating years. VIN also hosts an aquatic animal medicine message board for specific questions <<http://www.vin.com>>, as well as Rounds Topics, which is an interactive one-hour session dealing with basic and intermediate fish medicine issues (not for CE credit).

Other Courses

North Carolina State University: Fish Medicine Short Course, Raleigh, NC. Contact Gregory Lewbart

(greg_lewbart@ncsu.edu) or S. Hartford (919-513-6421; samantha_hartford@ncsu.edu) for more information.

State of Wisconsin: Aquaculture Veterinary Medicine for Practitioners Short Course. Contact Karen Meinholz (608-265-5206), for more information.

University of Florida: Two-Day Fish Health Management Workshops (Ruskin, FL, and Gainesville, FL). Contact Roy Yanong (rpy@ufl.edu).

University of Florida: Diseases of Warmwater Fish (Ruskin, FL, and St. Augustine, FL) (~2 weeks): <<http://conference.ifas.ufl.edu/ame>>

University of Florida, Advanced Fish Medicine (Gainesville, FL, and Orlando, FL) (~1 week): <<http://conference.ifas.ufl.edu/ame>>

University of Georgia: Koi Health Management (Athens, GA) (3 days): <<http://www.gactr.uga.edu/conferences/2004/Jan/23/koi.phtml>>

Ohio State University: CE in Fish Disease and Diagnostics (Piketon, OH) (2 days): <<http://www.ohiovma.org>>

Harbor Branch Oceanographic Institute: Aquatic Animal Health Management (Fort Pierce, FL) (3 days): <http://www.hboi.edu/aqua/acted_workshops.html>

Atlantic Veterinary College: Fish Disease Diagnostics for Practicing Veterinarians (Prince Edward Island) (1-4 weeks): <<http://www.upei.ca/avc/html/fish.html>>

US Fish and Wildlife Service <<http://training.fws.gov>>

- Fish Histology and Histopathology (course #FIS1350) <<http://training.fws.gov/catalog/fis1350.html>>
- Coldwater Fish Culture (course #FIS1100) that includes fish health lectures
- Warm and Coolwater Fish Culture (course #FIS1140) that includes fish health lectures
- Introduction to Fish Health (course #FIS1150)
- Fish Disease Diagnostic Techniques (course #FIS1250)

Mote Marine Laboratory: Diseases of Corals and Other Reef Organisms (Summerland Key, FL) (9 days): <http://isurus.mote.org/Keys/disease_workshop.phtml>

University of Arizona: Shrimp Pathology Short Course (Tucson, AZ) (2 weeks): <<http://microvet.arizona.edu/research/aquapath/index.htm>>

Harbor Branch Oceanographic Institute: ShrimpMed (Fort Pierce, FL) (3 days): <http://www.hboi.edu/aqua/training_pubs.html>

University of Queensland, Australia: Aquaculture (Health Management) Course: <<http://www.easonline.org.agenda/en/conf/conf283.asp>>

APPENDIX B: AVAILABLE INTERNSHIPS AND RESIDENCIES IN AQUATIC ANIMAL MEDICINE

Internship Programs

Mystic Aquarium & Institute for Exploration, Mystic, CT: <<http://www.mysticaquarium.org/>>

National Aquarium, Baltimore, MD: <<http://www.aqua.org/>>

The Florida Aquarium, Tampa, FL, and University of Florida, IFAS Tropical Aquaculture Laboratory, Ruskin, FL (joint program): <<http://www.flaquarium.org/>>; <<http://fishweb.ifas.ufl.edu/index.htm>>

Shedd Aquarium/Brookfield Zoo/Lincoln Park Zoo, Chicago, IL: <<http://www.sheddaquarium.org/>>, <<http://www.brookfieldzoo.org/>>, <<http://www.lpzoo.com/index2.html>>

Mississippi State University, Mississippi State, MS (predominantly catfish aquaculture and medicine): <<http://www.dafvm.msstate.edu/>>, <<http://www.msstate.edu/dept/tcnwac/>>

Residency Programs

North Carolina State University College of Veterinary Medicine, Raleigh, NC: Zoological Medicine residency (includes aquatic animals): <http://www.cvm.ncsu.edu/student-services/intern_resid/zoology.html>

University of Florida College of Veterinary Gainesville, FL: residency in aquatic animal health: <<http://www.vetmed.ufl.edu/>>

APPENDIX C: GENERAL REFERENCES FOR DIFFERENT AREAS OF AQUATIC ANIMAL MEDICINE

Invertebrates

Elston R. *Health Management, Development and Histology of Seed Oysters*. Baton Rouge, LA: World Aquaculture Society, 1999. 110 pp.

Kinne O, ed. *Diseases of Marine Animals*. 4 vols. New York: Wiley-Interscience, and Hamburg: Biologische Anstalt Helgoland.

Kraeuter JN, Castagna M, eds. *Biology of the Hard Clam*. San Diego, CA: Elsevier, 2001. 772 pp.

Lewbart GA, ed. *Invertebrate Medicine*. Ames, IA: Blackwell Publishing, 2006. 327 pp.

Mitsubishi J. *Invertebrate Tissue Culture Methods*. Tokyo: Springer-Verlag, 2002. 496 pp.

Mothersill C, Austin B. *Aquatic Invertebrate Cell Culture*. Chichester, UK: Springer Praxis, 2000. 409 pp.

Rosenberg E, Loya Y, eds. *Coral Health and Disease*. New York: Springer, 2004. 488 pp.

Stolen JS, Fletcher TC, Smith SA, Zelikoff JT, Kaattari SL, Anderson RS, Soderhall K, Weeks-Perkins BA. *Techniques in Fish Immunology*. Fair Haven, NJ: SOS Publications, 1995. 258 pp. plus appendices.

Fish

Brown L. *Aquaculture for Veterinarians: Fish Husbandry and Medicine*. Oxford: Pergamon Press, 1993. 462 pp.

Leatherland JF, Woo PTK, eds. *Fish Diseases and Disorders*, vol. 2: *Non-infectious Disorders*. New York: CABI Publishing, 1999. 400 pp.

Noga EJ. *Fish Disease Diagnosis and Treatment*. St. Louis, MO: Mosby-Yearbook, 1996. 367 pp.

Plumb JA. *Health Maintenance and Principal Microbial Diseases of Cultured Fishes*. Ames: Iowa State University Press, 1999. 328 pp.

Stoskopf MK, ed. *Fish Medicine*. Philadelphia: W.B. Saunders, 1993. 882 pp.

Wildgoose W. *British Small Animal Veterinary Association Manual of Ornamental Fish*, 2nd ed. Gloucester, UK: BSAVA, 2001. 304 pp.

Woo PTK, ed. *Fish Diseases and Disorders*, vol. 1: *Protozoan and Metazoan Infections*. New York: CABI Publishing, 1994. 816 pp.

Woo PTK, Bruno DW, eds. *Fish Diseases and Disorders*, vol. 3: *Viral, Bacterial, and Fungal Infections*. New York: CABI Publishing, 1998. 896 pp.

Species/Group Specific

Hoole D, Bucke D, Burgess P, Wellby I. *Diseases of Carp and other Cyprinid Fishes*. Osney Mead, UK: Fishing News Books (Blackwell Science), 2001. 264 pp.

Johnson EJ. *Koi Health and Disease*. Marietta, GA: Johnson Veterinary Services, 1997. 141 pp.

Roberts RJ, Shepherd CJ. *Handbook of Trout and Salmon Diseases*, 3rd ed. Oxford: Fishing News Books, 1997. 179 pp.

Saint-Erne N. *Advanced Koi Care*. Glendale, AZ: Erne Enterprises, 2003. 194 pp.

Sindermann CJ. *Principal Diseases of Marine Fish and Shellfish: Diseases of Marine Fish*, vol. 1, 2nd ed. San Diego, CA: Academic Press, 1990. 521 pp.

Sindermann CJ. *Principal Diseases of Marine Fish and Shellfish: Diseases of Marine Shellfish*, vol. 2, 2nd ed. San Diego, CA: Academic Press, 1990. 519 pp.

Microbiology of Fish Diseases

Austin B, Austin DA. *Bacterial Fish Pathogens*, 3rd ed. Chichester, UK: Springer-Praxis, 1999.

Inglis V, Roberts RJ, Bromage NR. *Bacterial Diseases of Fish*. New York: Halsted Press/Wiley/Blackwell Scientific, 1993. 312 pp.

Whitman K. *Finfish and Shellfish Bacteriology Manual: Techniques and Procedures*. Ames, IA: Blackwell/Iowa State University Press, 2004. 258 pp.

Wolf K. *Fish Viruses and Fish Viral Diseases*. Ithaca, NY: Cornell University Press, 1988. 476 pp.

Histology/Pathology

Ferguson HW. *Systemic Pathology of Fish*. Ames: Iowa State University Press, 1989. 263 pp.

Howard DW, Lewis EJ, Keller BJ, Smith CS: *Histological Techniques for Marine Bivalve Mollusks and Crustaceans*. NOAA Technical Memorandum NOS NCCOS5NOAA, Oxford, MD, 2004. 218 pp.

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Miscellaneous

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Systems

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Stickney RR. *Principles of Aquaculture*. New York: Wiley, 1994. 502 pp.

Timmons MB, Losordo TM. *Aquaculture Water Reuse Systems: Engineering Design and Management*. San Diego, CA: Elsevier Science, 2000. 346 pp.

Wheaton FW. *Aquacultural Engineering*. Melbourne, FL: Krieger Publishing, 1993. 728 pp.

APPENDIX D: AQUATIC ANIMAL HEALTH/MEDICINE JOURNALS

Journal of Aquatic Animal Health (American Fisheries Society, Fish Health Section)

Journal of Fish Diseases

Diseases of Aquatic Organisms

Exotic DVM Magazine

Journal of the Fish Veterinary Society (UK)

Veterinary Clinics of North America, Exotic Animal Practice (contain aquatic animal-specific review articles)

Seminars in Avian and Exotic Pet Medicine (contain aquatic animal-specific review articles)

Journal of Invertebrate Pathology

Journal of Wildlife Diseases

Journal of Zoo and Wildlife Medicine

APPENDIX E: OTHER USEFUL AQUATIC MEDICINE RESOURCES

Fact Sheets/Circulars

University of Florida (UF), Institute of Food and Agricultural Sciences (IFAS), Electronic Data Information Source (EDIS): <<http://edis.ifas.ufl.edu/deptlist.html>> (aquatic animal medicine-related fact sheets can be found by entering through the Veterinary Medicine link and the Fisheries and Aquatic Sciences link).

University of Florida Circular: *Florida Aqua News* (for aquatic animal veterinarians): <<http://fishweb.ifas.ufl.edu/Petty/Petty.htm>>

Commercial Fish and Shellfish Technology (CFAST): <<http://www.cfast.vt.edu/Publications/newsletters.shtml>>

USDA, APHIS, Veterinary Services: <<http://www.aphis.usda.gov/vs/aqua/>>

Regional Aquaculture Centers:

- Southern Regional Aquaculture Center (SRAC): <<http://www.msstate.edu/dept/srac/fslist.htm>>
- North Central Regional Aquaculture Center (NCRAC): <http://aquanic.org/publicat/usda_rac/efs/ncrac.htm>
- Western Regional Aquaculture Center: <<http://www.fish.washington.edu/wrac/>>

- Northeastern Regional Aquaculture Center: <<http://www.old.umassd.edu/specialprograms/nrac/>>
- Tropical and Subtropical Regional Aquaculture Center: <<http://www.ctsa.org/PublicationList.aspx?type=fact>>

Web Sites

Coral Health and Monitoring Program (CHAMP): <http://www.coral.noaa.gov/coral_disease/cdhc.shtml>

Shellfish Diseases: <http://www.pac.dfo-mpo.gc.ca/sci/shelldis/toc_e.htm>

Trout Histology Image Collection, USFWS: <<http://training.fws.gov/BART/fish/histo1.html>>

Atlas of Normal Fathead Minnow Histology: <<http://aquaticpath.umd.edu/fhm/index.html>>

Diseases of Zebrafish in Research Facilities: <<http://zfin.org/zirc/disMan/diseaseManual.php>>

Video

Watson CA. *Fish Health Management* [6-video series]. University of Florida Cooperative Extension Service, FTFFA, Pet Care Trust, 1996 <<http://www.petsforum.com/petcaretrust/PCTE2.htm>>. (Now available on DVD)

DVD

Durborow R. *Diseases of Warmwater Fish and Trout Diseases*. Kentucky State University Aquaculture Program, USDA, 2001. DVD available through the World Aquaculture Society <<http://www.was.org>>.