Conservation Biology of

AMPHIBIANS OF ASIA

Conservation Biology of

AMPHIBIANS OF ASIA

Status of Conservation and Decline of Amphibians: Eastern Hemisphere

Edited by

Harold Heatwole and **Indraneil Das**

Natural History Publications (Borneo)
Kota Kinabalu

2014

Published by

Natural History Publications (Borneo) Sdn. Bhd. (216807-X)
A913, 9th Floor, Wisma Merdeka Phase 1,
P.O. Box 15566,
88864 Kota Kinabalu, Sabah, Malaysia.
Tel: 088-233098 Fax: 088-240768
e-mail: info@nhpborneo.com
website: www.nhpborneo.com

First published July 2014.

Conservation Biology of Amphibians of Asia
Edited by Harold Heatwole and Indraneil Das

This is Volume 11, Part 1, of Amphibian Biology

ISBN 978-983-812-154-5

Printed in Taiwan.

Contents

On Amphibian Biology

There are several outstanding treatises of amphibian biology. “Biology of Amphibians” (Duellman and Trueb 1986) is an excellent general work, clearly written and well illustrated, and with a remarkable depth and breadth for a single volume. It will be the standard general reference on amphibians for many years to come and the present generation of herpetologists will consider it the “amphibian bible” much as their predecessors regarded G.K. Noble’s (1931) “The Biology of the Amphibia”. No single volume, however, fulfils the need for a sequential, monographic treatment of specialized topics.

A few individual subjects have been treated in considerable depth. These include the three volumes of “Physiology of the Amphibia” (Moore 1964; Lofts 1974, 1976), “Frog Neurobiology, a Handbook” (Llínas and Precht 1976) and “The Reproductive Biology of Amphibians” (Taylor and Guttman 1977), but it has now been many years since these appeared and many topics are in need of updating. “Environmental Physiology of the Amphibians” (Feder and Burggren 1992) did that for some aspects and treated other new ones, but it too is now getting out of date. Two books, “Patterns of Distribution of Amphibians” (Duellman 1999) and “Tadpoles” (McDiarmid and Altig 1999) closed out the 20th century with excellent reviews of amphibian biogeography and of the biology of larval amphibians, respectively. Starting the millennium was a multi-volume treatment of reproductive biology and phylogeny: “Reproductive Biology and Phylogeny of Urodela” (edited by David M. Sever) and “Reproductive Biology and Phylogeny of Anura” (edited by Barrie Jamieson), both in 2003, followed by “Reproductive Biology and Phylogeny of Gymnophiona” (edited by Jean-Marie Exbrayat) in 2004. Reproduction was further treated by Ogielska (2009) in “Reproduction of Amphibians”. Finally, Hillman *et al*. (2009) reviewed the physiological ecology of amphibians in “Ecological and Environmental Physiology of Amphibians”. Recent molecular techniques led to a rearrangement of amphibian taxonomy (Frost *et al*. 2006). “Behaviour and Ecology of Amphibians” was a recent, comprehensive, thoughtful update (Wells 2007). Collectively, all the above works, excellent though they are, still leave large, unaddressed gaps in amphibian biology.

Recognizing that the discipline of amphibian biology had reached sufficient maturity to warrant detailed, multi-volume review and that such a need had been filled only partly, and with no commitment to continuation, the present series, “Amphibian Biology”, was launched in 1994. The present volume represents part of the eleventh in the series. “Amphibian Biology” does not compete with the titles mentioned above. Topics recently reviewed elsewhere are not covered in current volumes, but are reserved for such time as further update is required.

The need for this series was evidenced by the enthusiastic response from potential authors. Of the 64 people contacted with invitations to contribute to the first few volumes, only three declined, and then because of heavy commitments otherwise. Most expressed the view that such a series was long overdue. With this initial encouragement the series was launched and it is continuing to enjoy undiminished support.

Amphibian Biology was inspired by “Biology of the Reptilia” (1969–2010), edited by Carl Gans, and is intended as a companion to that series. “Biology of the Reptilia” is a unique, monumental contribution to herpetology and has become the most authoritative single source of information on reptiles that is available. Comprehensive treatments of all aspects of reptilian biology are presented in detail and are exhaustively documented by literature. It has been, and continues to be, invaluable. It is hoped that “Amphibian Biology” will serve herpetologists in the same way and that it will maintain the high standard set by its reptilian counterpart.

Harold Heatwole
Series Editor
Raleigh, North Carolina, USA
July 2012

References

Duellman, W.E., 1999. “Patterns of Distribution of Amphibians”. The John Hopkins University Press, Baltimore.

Duellman, W.E. and Trueb. L., 1986. “Biology of Amphibians”. McGraw-Hill Book Company, New York.

Exbrayat, J.-M. (ed.), 2004. “Reproductive Biology and Phylogeny of Gymnophiona”. Science Publishers, Enfield.

Feder, M.E. and Burggren, W., (eds.), 1992. “Environmental Physiology of the Amphibians”. University of Chicago Press, Chicago.

Frost, D.R., Grant, T., Faivovich, J., Bain, R., Haas, A., Haddad, C.F.B., de Sa, R., Channing, A., Wilkinson, M., Donnellan, S.C., Raxworthy, C., Campbell, J.A. , Blotto, B.L., Moler, P., Drewes, R.C., Nussbaum, R.A., Lynch, J.D., Green, D.M. and Wheeler, W., 2006. The amphibian tree of life. Bulletin of the American Museum of Natural History 297: 1–370

Gans, C. (ed.), 1969–2010. “Biology of the Reptilia”. 22 vols, Academic Press, New York; Alan R. Liss, Inc., New York; The University of Chicago Press, Chicago; Society for the Study of Amphibians and Reptiles.

Hillman, S.S., Withers, P.C., Drewes, R.C and Hillyard, S.D., 2009. “Ecological and Environmental Physiology of Amphibians”. Oxford University Press, Oxford.

Jamieson, B.G.M. (ed.), 2003. “Reproductive Biology and Phylogeny of Anura”. Science Publishers, Enfield.

Llins, R. and Precht, W., 1976. “Frog Neurobiology, a Handbook”. Springer-Verlag, Berlin.

Lofts, B. (ed.), 1974. “Physiology of the Amphibia”, volume 2. Academic Press, New York.

Lofts, B. (ed.), 1976. “Physiology of the Amphibia”, volume 3. Academic Press, New York.

McDiarmid, R.W. and Altig, R., 1999. “Tadpoles”. The University of Chicago Press, Chicago.

Moore, J.A. (ed.), 1964. “Physiology of the Amphibia”. Academic Press, New York.

Noble, G.K., 1931. “The Biology of the Amphibia”. McGraw-Hill Book Company, New York.

Ogielska, M. (ed.), 2009. “Reproduction of Amphibians”. Science Publishers, Enfield.

Sever, D.M. (ed.), 2003. “Reproductive Biology and Phylogeny of Urodela”. Science Publishers, Enfield.

Taylor, D.H. and Guttman, S.I. (eds.), 1977. “The Reproductive Biology of Amphibians”. Plenum Press, New York.

Wells, K.D., 2007. “The Ecology and Behavior of Amphibians”. The University of Chicago Press, Chicago.

Preface

The late 20th century and the early 21st century has been characterized by an unprecedented deterioration of the environment of the earth and the throes of one of the major extinction events of all time. Unmitigated deforestation, desertization, erosion and salinization of soil, pollution of water and air, and thinning of the UV-protective ozone layer constitute dire ecological threats for life on the planet. Fossil carbon is being returned to the atmosphere at an accelerated rate with a concomitant change in the earth's climate that is likely to make serious inroads into ecological stability.

The human population now exceeds the long-term carrying capacity of the earth and is able to subsist at its present levels only because it is sustained by fossil resources of energy, soil, water, and even oxygen. With continuing decrease in biodiversity, progressive destruction of essential habitats, degradation of major ecosystems, and contamination of life-support systems, it is likely that the carrying capacity of the earth will decline below present levels — while at the same time the human population continues to rise. The outstripping of even its fossil resources, likely to occur within the present century, presents a bleak outlook for our own species. We may well become a victim ourselves of this most recent mass extinction.

While it is undisputable that many aspects of environmental degradation and loss of biodiversity is directly attributable to unwise human activities, other aspects are deemed to result from natural cycles beyond the influence of mankind. It is important to be able to distinguish between the two, so that attention can be focused on mitigating those effects over which we do have control. It is important to ascertain the causes of particular declines and extinctions as soon as possible, so that steps can be taken to preserve what diversity we can.

Amphibians, by virtue of their thin, moist, permeable skins, are poorly protected from harsh environments and are especially susceptible to chemical changes, desiccation, and habitat alteration. Accordingly, it is not surprising that they have manifest proportionately high extinction rates and suffer more severe declines than most other taxa. They are especially important to study as they serve as an early-warning system portending changes that may soon engulf more resistant species, including our own.

There are various websites that indicate the status of amphibians at a particular time and place. These websites change as status changes. The present volumes do not compete with those. Volumes nine and 11 indicate the status at the time of publication, but in addition provide an historical baseline — a sort of time-capsule. In one sense, because species of amphibians are going extinct while chapters are being written and put to press, volumes nine and 11 will already be going out of date by the time they are published. In another sense, however, they are timeless as one can return to them for information on the status at a particular time and as a baseline for assessing subsequent extents and rates of change.

Volumes eight and ten were devoted to an elucidation of the myriad of factors responsible for amphibian decline and extinction and an assessment of measures that can be taken to conserve this important taxon. Volume nine assessed the status of amphibian decline and extinction in the Western Hemisphere, and the present one (vol. 11) does so for the Eastern Hemisphere.

The nomenclature of amphibians is in a state of flux and different authors agree to varying extents with some of the more recent changes. Consequently, no attempt was made to standardize nomenclature and so names of some taxa will vary from one chapter to another. In time, perhaps a greater agreement will be reached than is possible at the present moment.

Harold Heatwole
Raleigh, NC
Revised 20 December 2012

Dedication to Ermi Zhao

Effective conservation is based on sound systematics as well as on detailed distributional and field studies. It has not been possible to properly assess the true conservation status of the amphibians and reptiles of China — which occupies about 6.5 percent of the earth's surface area and is home to nearly 7.0 percent of its herpetofauna — until recently. More so than to anyone else, this change has been due to one person. He was the first to take a nationwide approach to Chinese herpetology by conducting personal fieldwork throughout the country; by building the most comprehensive museum reference collection of Chinese amphibians and reptiles; by his authorship or editorship of major works on the systematics, biology, and conservation of China's herpetofauna; by founding and editing Chinese herpetological journals; and by establishing internationally recognized scientific standards for herpetological studies in his country. For these reasons, among many others, this volume is dedicated to Ermi Zhao.

Zhao was born in 1930 in Chengdu, in the agriculturally rich Sichuan Basin of southwestern China. He studied biology at West China Union University in Chengdu where he had the good fortune to study with Cheng-chao Liu (West China Union changed its name to Sichuan Medical College in 1950 and then to West China University of Medical Science in 1985). Liu, who had received his doctorate at Cornell University in the United States in 1934, became China's leading herpetologist, a specialist on amphibians, and a dedicated field biologist. He published an elaborate English-language monograph on the amphibians of Western China in 1950 and became president of Sichuan Medical College the next year. Zhao's own fieldwork began in 1948 at Mt. Jiufeng in western Sichuan. He was also mentored by the acknowledged founder of modern biology in China, Chih Ping, who specialized on reptiles. Zhao began his correspondence with Ping, who worked in Beijing, in 1948. Ping, like Liu, was a Cornell graduate and both of them became academicians of Academia Sinica, the elite Chinese academy of sciences. The influence of these two outstanding and well-trained scientists provided Zhao with a broad foundation in zoology and a deep appreciation for the fundamental importance of careful field observations.

Zhao graduated from Sichuan Medical College in 1951. He then became an assistant at Harbin Medical University in Heilongjiang Province in extreme northeastern China, but returned to Chengdu three years later as lecturer at his alma mater where he became associated with Liu again. In 1965, Zhao moved to the Sichuan Biological Research Institute (today, the Chengdu Institute of Biology, a division of Academia Sinica) where he founded the herpetological program and was head of the institute's Department of Herpetology from 1978 to 1987. He rose through the ranks to the post of scientist (research professor) in 1986 and served as deputy director of the Chengdu Institute from 1982 to 1993. He was elected an academician of Academia Sinica in 2001. Although he has retired from his leadership duties at the institute, he remains active scientifically.

Zhao began a steady stream of publications on amphibians and reptiles in 1965 (in the mid-1970s, personal authorship was not permitted in China; instead, credit was given to work units such as Zhao's institute). He authored works on various aspects of biology, but increasingly his focus was on systematics and distribution. This was what was most needed at that time in China. Zhao was able to conduct major expeditions on a nearly annual basis thereafter and, despite suffering a very serious leg injury in 1993, he continues his fieldwork even today. He has visited all parts of his vast country, from Yunnan and Hainan in the tropical south to Inner Mongolia and Xinjiang in the arid north, as well as to Xizang (Tibet) and even Taiwan. Following in the tradition of his teacher, Cheng-chao Liu, his attention to natural history in the field — especially to breeding dates, vocalizations, and other aspects of reproductive biology — was invaluable for his work in systematics and, later, that in conservation.

As author or editor, Zhao has published 32 books and other major works (as well as more than 160 technical papers) on amphibians and reptiles. These have established him as China's preeminent living herpetologist. To satisfy utilitarian needs, his earliest books were keys for the identification of Chinese snakes (1972), reptiles (1977), and amphibians and reptiles (1986). Three additional practical works deal with the use of amphibians and reptiles for food, traditional medicine, and other economic purposes (1978, 1982, 1985). Another trio of books

treat venomous snakes, venoms, envenomation, and treatment of snakebite (1974, 1979, 1985). Among his general herpetological titles is "Colour Book of Chinese Snakes" (1980), a book written with seven other authors that was the first of Zhao's books to become well known outside China. He also co-authored an encyclopedia of nature for children (1986), a volume on amphibians and reptiles in a series of illustrated books on Chinese animals (1987), and a semi-popular colour atlas for the identification of the turtles of the world (2004).

Among Zhao's most technical herpetological books are monographs on species or groups of species: the Sharp-nosed Viper (*Deinagkistrodon acutus*), a work detailing this large viper's biology, morphology, ecology, and toxicology (1982), and a detailed study of Chinese salamanders (1984; English edition 1988). He has also authored or co-authored books on specific regions of China including Xizang (1987), the Hengduan Mountains of the high Qinghai-Xizang Plateau (1997), and an atlas of Sichuan reptiles (2003), which includes spectacular coloured photographs of animals and landscapes. "Amphibians and Reptiles of Tibet," his most recent book, appeared in 2010.

Zhao's most widely known book, "Herpetology of China" (1993), is the first work in any language that covers all of the amphibians and reptiles of China including Hong Kong and Taiwan — 661 species at that time — with an historical account, keys, synonymies, distribution, bibliography, gazetteer, and hundreds of coloured photographs of animals and their habitats. Zhao is also the principal author of two technical volumes in the "Fauna Sinica" series (snakes, 1998; lizards, 1999). He was sole author of a magnificently produced, large-format book in two volumes, "Snakes of China" (2006), that includes general biology, keys, and descriptions of taxa, and is lavishly illustrated with hundreds of colour photographs.

As a special service to his country's herpetological community, Zhao was the main author of several indices and bibliographic reference works including the compendium, "Latin–Chinese–English Names of Amphibians and Reptiles" (1993; second edition 1998), a cross-indexed list of "Chinese Herpetological Literature" (1994), and "Taxonomic Bibliography of Chinese Amphibia and Reptilia, including Karyological Literature" (2000), which contains an up-to-date checklist of Chinese amphibians and reptiles.

As a further contribution to his colleagues in China and abroad, Zhao has edited collections of herpetological papers that were dedicated to two of the great classical Chinese herpetologists, Zhao's former teacher, Cheng-chao Liu (1990), and Mang-ven L.-Y. Chang (1992), author of the first comprehensive monograph of Chinese salamanders (1936; reissued 1968). Zhao also edited the conference papers from the first two Asian Herpetological Meetings (1993, held in Huangshan, China; 1995, held in Ashgabat, Turkmenistan) and another volume on Chinese turtle research (1997) that commemorated the return of Hong Kong to Chinese sovereignty. As a further tribute to Liu and a great aid to herpetologists of all countries, Zhao edited a reprint volume of Liu's technical papers (2000), mostly on taxonomy and basic natural history data about Chinese frogs. The volume includes Liu's papers originally published in the Peking Natural History Bulletin (Beijing) and the Journal of the West China Border Research Society (Chengdu) that are otherwise not generally available to today's workers.

Zhao began his conservation work in the late 1970s. He became a member of the editorial board of Chinese Wildlife (Harbin) in 1979 and six years later also joined the editorial board of Resources Development and Conservation (Chengdu). During 1991–1993, he served as chairman of the China Reptiles and Amphibians Specialist Group of the Species Survival Commission (International Union for Conservation of Nature). His major work on the conservation of Chinese amphibians and reptiles was as chief compiler of the book, "Chinese Red Data Book of Endangered Animals: Amphibia and Reptilia" (1998). This volume lists 29 amphibian and 96 reptilian species as endangered including a few, such as the Saltwater Crocodile (*Crocodylus porosus*), that are already extirpated in China.

In addition to the numerous books that he has authored or edited, Zhao was the principal organizer of journals, societies, and meetings established to promote herpetology in China and create a greater awareness of Chinese herpetological studies overseas. He was editor of the first Chinese herpetological periodical, the exclusively Chinese-language "Materials for Herpetological Research" (1972–1978) and also edited its successors, "Acta Herpetologica Sinica" (1979–1988), which has extensive English abstracts, and "Chinese" (later, Asiatic, and now Asian) "Herpetological Research" (1987 to date), which is entirely in English. Zhao was one of the founders of the Herpetological Society of China in 1982. Four years later he founded the Chinese Society for the Study of Amphibians and Reptiles (CSSAR), which has a more international outlook. CSSAR was a co-sponsor of Asiatic Herpetological Research and organized several international herpetological meetings in China beginning in 1993.

Furthermore, CSSAR, under Zhao's editorship, has now published 16 books in the society's "Herpetological Series", which began in 1990. It should be noted that the meetings have been conducted in English and the books written with extensive English abstracts, as the *lingua franca* of international science. Using these methods, Ermi Zhao has connected the Chinese herpetological community to the international community and established globally recognized standards for herpetological science in China. This is an achievement that required great focus, energy, and personal skill.

Zhao has also travelled extensively overseas — throughout North America, Europe, and Asia — to scientific meetings and to work with foreign colleagues at museums and universities. He served on the executive committee for the First World Congress of Herpetology, which was held in the United Kingdom in 1989. He was thus the first Chinese scientist to hold a post in an international herpetological organization. In 2008, the American Society of Ichthyologists and Herpetologists, the world's oldest herpetological society, elected him to Honorary Foreign Membership, only the second Chinese herpetologist to be so honoured (his beloved teacher, Cheng-chao Liu, was the first).

Ermi Zhao's extraordinary dedication to Chinese herpetology and herpetological conservation are unmatched. We are pleased to acknowledge his contributions to international herpetological science and conservation. This book is, therefore, a most fitting tribute to him in his mid-eighties.

Kraig Adler
Cornell University
17 January 2011

Contributors

ALCALA, Angel C., Angelo King Center for Research and Environmental Management Silliman University, Marine Laboratory, Bantayan, 6200, Dumaguete City, Philippines.
Email: suakcrem@yahoo.com

ALLISON, Allen, Bishop Museum, 1525 Bernice Street, Honolulu, Hawaii 96817, USA.
Email: allison@hawaii.edu

BROWN, Rafe M., Department of Ecology and Evolution and KU Biodiversity Institute, 1345 Jayhawk Boulevard, Dyche Hall, University of Kansas, Lawrence, KS 66045, USA.
Email: rafe@ku.edu

CHENG Li, Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China.
Email: licheng@cib.ac.cn

CHUAYNKERN, Yodchaiy, Thailand Natural History Museum, National Science Museum, Technopolis, Thailand.
Email: ychuaynkern@yahoo.com

DAS, Indraneil (Co-Editor), Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.
Email: idas@ibec.unimas.my

DIESMOS, Arvin, Herpetology Section, Zoology Division National Museum of the Philippines Padre Burgos Avenue, Ermita 1000 Manila, Philippines.
Email: arvin.diesmos@gmail.com

DUENGKAE, Prateep, Department of Forest Biology, Kasetsart University, Jatujak Bangkok 10900, Thailand.
Email: prateep.du@ku.ac.th

FENG Xie, Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China.
Email: xiefeng@cib.ac.cn

GRAFE, T. Ulmar, Department of Biology, Faculty of Science, Jalan Tungku Link, Gadong BE1410, Universiti Brunei Darussalam, Brunei Darussalam.
Email: grafe@biozentrum.uni-wuerzburg.de

DUTTA, Sushil K., Centre for Ecological Sciences, New Biological Sciences Building Indian Institute of Science, Bangalore 560 012, Karnataka, India.
Email: dutta@ces.iisc.ernet.in

DODD, C. Kenneth, Jr., Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida 32611, USA.
Email: Terrapene600@gmail.com

FENG Xie, Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China.
Email: xiefeng@cib.ac.cn

HEATWOLE, Harold (Co-Editor), Department of Biology, North Carolina State University, Raleigh, NC 27695-7617, USA.
Email: harold_heatwole@ncasu.edu

ISKANDAR, Djoko T., Sekolah Ilmu dan Teknologi Hayati, Institut Teknologi Bandung Labtek XI, Jalan Ganesa 10, Bandung 40132, Indonesia.
Email: iskandar@sith.itb.ac.id; dtiskandar@gmail.com

JIANPING Jiang, Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China.
Email: jiangjp@cib.ac.cn

KAISER, Christine M., Department of Biology, Anne Arundel Community College, 101 College Parkway, Arnold, Maryland 21012, USA.
Email: 0000000

KAISER, Hinrich, Department of Biology, Victor Valley College, 18422 Bear Valley Road, Victorville, California 92395, USA.
Email: kaiserh@vvc.edu

KAPLAN, Robert H., Reed College, Department of Biology, Portland, OR 97202, USA.
Email: Robert.Kaplan@reed.edu

KHAN, Muhammad Sharif, 306 North Morton Avenue, Morton, PA 19070, USA.
Email: typhlops99@outlook.com

KUZMIN, Sergius L., Institute of Ecology and Evolution, Russian Academy of Sciences, Leninsky Prospect, 33, 119071 Russia.
ipe51@yahoo.com

LASATER, Kelly C., College of Veterinary Medicine, Seoul National University, Seoul 151-742, South Korea.
atrox@crotalus.us

LEONG, Tzi Ming, Department of Biological Sciences, National University of Singapore, Kent Ridge, 19260, Singapore.
banjarana@gmail.com

MATSUI, Masafumi, Graduate School of Human and Environmental Studies, Kyoto University, Sakyo, Kyoto 606-8501, Japan.
fumi@zoo.zool.kyoto-u.ac.jp

MANAMENDRA-ARACHCHI, Kelum, Alawala Prehistoric Cave Project, Postgraduate Institute of Archeology, University of Kelaniya, 407 Bauddhaloka Mawatha, Colombo 7, Sri Lanka.
Onlinecss.kelum@gmail.com

MEERGASKUMBURA, Madhava, Department of Zoology, University of Peradeniya, Sri Lanka.
madhava_m@mac.com

MIN, Mi-Suk, College of Veterinary Medicine, Seoul National University, Seoul 151-742, South Korea.
minbio@snu.ac.kr

O'SHEA, Mark, West Midland Safari Park, Bewdley, Worcestershire DY12 1LF, UK and Australian Venom Research Unit, Pharmacology Department, University of Melbourne, Parkville, Victoria 3010, Australia.
oshea@markoshea.info

PARK, Daesik, Division of Science Education, Kangwon National University, Chuncheon, Kangwon 200-701 South Korea.
Parkda@kangwon.ac.kr

PETHIYAGODA, Rohan, Ichthyology Section, Australian Museum, 6 College St., Sydney NSW 2010, Australia.
rohanpet@gmail.com

REZA, A.H.M. Ali, Department of Biology (Wildlife Management), Delta State University, Cleveland, MS 38733, USA.
areza@deltastate.edu

ROWLEY, Jodi J.L., Terrestrial Vertebrates, Australian Museum, 6 College St., Sydney, NSW 2010, Australia.
jodi.rowley@austmus.gov.au

SHAH, Karan B., Natural History Museum, Tribhuvan University, Swayambhu, Kathmandu, Nepal.
prof.karan@gmail.com

SILER, Cameron D., Sam Noble Museum and Department of Biology, University of Oklahoma, 2401 Chautauqua Ave., Norman, OK 73072-7029, USA.
camsiler@ou.edu

SON, Sang-Ho, Jeokgok-Ri, JangPyeong-Myeon, CheongYang-Gun, ChungNam 345-833, South Korea.
malgnm@naver.com

SONG, Jae-Young, Korea National Park Research Institute, Korea National Park Service, Namwon, JeonBuk 590-811, South Korea.
song@seoul.korea.com.

STUART, Bryan L., Section of Research & Collections, North Carolina Museum of Natural Sciences, 11 West Jones Street, Raleigh, NC 27601, USA.
bryan.stuart@naturalsciences.org

SUH, Jae-Hwa, Department of Nature and Ecology Research, National Institute of Environmental Research, Incheon 404-708, South Korea.
amphibia@me.go.kr or amphibia@korea.kr

SUKUMARAN, Jeet, Department of Biology, Duke University, Box 90338, Durham, NC 27708, USA.
jeet.sukumaran@duke.edu

WANGYAL, Jigme Tshelthrim, Office of the District Forest Officer, District Administration, Trashigang, Bhutan.
jigmewangyal@gmail.com

WOGAN, Guinevere O.U., Museum of Vertebrate Zoology, 3101 Valley Life Sciences Building, University of California Berkeley, Berkeley, CA 94720, USA.
Frog.girl@gmail.com

YAAKOB, Norsham, Forest Research Institute Malaysia, 52109 Kepong, Selangor, Malaysia.
norsham_yaakob@yahoo.com

CHAPTER 1

Changes in Amphibian Populations in the Commonwealth of Independent States and Georgia (Part of the Former Soviet Union)

Sergius L. Kuzmin and C. Kenneth Dodd Jr.

Abbreviations and acronyms used in the text and references: CIS = Commonwealth of Independent States; DAPTF = Declining Amphibian Populations Task Force; IUCN = International Union for the Conservation of Nature; SSC = Species Survival Commission; USSR = Union of Soviet Socialist Republics.

I. INTRODUCTION

Studies on amphibian ecology in the former Union of Soviet Socialist Republics (USSR) have been conducted for many decades, beginning with the early investigations by A.M. Nikolsky and others (Kuzmin 1999 & 2013). The political disintegration of the USSR led to the formation of the Commonwealth of Independent States (CIS) that now includes all former member states within the USSR exclusive of the three Baltic republics (Estonia, Latvia, Lithuania, and Georgia). This chapter reviews the status of amphibian populations throughout the CIS, an area occupying a large part of the Northern Palaearctic, including the entire region of northern Asia. Included are the republics of Russia, Belarus, Ukraine, Armenia, Azerbaijan, Moldova, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Turkmenistan. In 2009, when the main part of this chapter was finished, Georgia left the CIS. This is why this chapter is called “the CIS and Georgia”.

Many publications, including several general reviews, have been published in the past decade concerning the problem of amphibian declines in the CIS, especially since the establishment of the IUCN/SSC/DAPTF Regional Group for the Commonwealth of Independent States in 1992 (Kuzmin 1994a; Kuzmin *et al.* 1995; Vershinin 2001). As have others when reviewing a large amount of data compiled by many researchers in many different ways, several problems were faced in evaluating this information, such as how to distinguish between steady declines and temporary fluctuations in abundance, how to determine the extent of declines, and how to determine the reliability of the supporting data on which perceptions of declines were based.

Unfortunately, answers to these questions were not always clear from a critical evaluation of the published literature. A comparative analysis, however, permitted making a number of conclusions on population trends among different regions of the CIS. This review examines publications from nearly all the republics of the former USSR. Papers with information on population numbers but without dynamic context were not used. The format (that of Kuzmin 1994a) from the first overview of amphibian declines in the former Soviet Union was followed, albeit with updated information and critical evaluation.

Population changes may be analyzed on long-term or short-term time-scales. The former conventionally includes changes in an historical or geological time-frame and may cover hundreds to millions of years. The latter includes changes from less than a year up to a century and is usually assessed in terms of fluctuations in abundance or relatively recent changes in distribution.

II. LONG-TERM CHANGES

Past global and regional climatic change has certainly influenced amphibian abundance and distribution and will likely do so in the future. A large proportion of contemporary Eurasian amphibian species already existed in the region of the CIS from the late Pliocene throughout the Pleistocene (Holman 1998). Glacial expansion and retreat, with an accompanying expansion or reduction in the extent of forests and steppes during the past 600,000 to 700,000 years, had a great impact on amphibian distribution and dynamics (Borkin 1984). For example, fossils from Quaternary deposits resembling those of *Salamandrella keyserlingii* have been found on the East-European Plain much farther to the southwest than the species’ contemporary range (Ratnikov 1989, 2002). Quaternary records for the following species indicate a much greater palaeogeographic distribution than the species presently occupies: *Pelobates syriacus* in Moldova and Ukraine (presently only in the Caucasus); *Bufo verrucosissimus* in Moldova (presently only in the Caucasus); *Bufo calamita* in Moldova (presently only west of the former USSR); *Bufo raddei* in Moldova, Ukraine, northeastern Kazakhstan (presently in Transbaikalia and the Far East); *Rana dalmatina* in Belarus (presently only in Transcarpathia) (Ratnikov 2003). In addition, many fossils of Quaternary salamanders and frogs attributed to extinct species have been found on the East-European Plain.

Fossils of the salamander *Ranodon* cf. *sibiricus* have been found much farther west than the current range of the nominal species, which suggests that these salamanders once occupied wide geographic areas in Central Asia. The current long-term decline and localized extirpation of *R. sibiricus* has been caused not only by anthropogenic influences (described below) but also by the increasing aridity of the climate of southern Kazakhstan (Kuzmin and Thiesmeier 2001). It seems likely, then, that a number of natural extinctions have occurred within the amphibian fauna of the former USSR during past geological epochs.

More recent climatic changes also have affected amphibians in the CIS, perhaps within the past few thousand years. For example, species from the northern taiga, such as *Salamandrella keyserlingii,* occurred in Tatarstan, an area in the eastern part of central European Russia, during cold periods, whereas more temperate species such as *Hyla orientalis* occurred there during warm periods (Garanin 1989).

On the other hand, forest species such as *Triturus cristatus*, *Bufo bufo*, and *Rana temporaria*, have receded northwards because of the destruction of forests. An increase in agriculture between the 5th and 13th centuries and even later may have facilitated the northward expansion of southern species such as *Bombina bombina* and *Pelobates fuscus* (Garanin 1989). Thus, long-term changes in climate and landscape have influenced current distributional patterns in different ways according to the specific ecological requirements and dispersal capabilities of the species involved.

III. SHORT-TERM CHANGES

A. Declines of Populations and Species

Declines have been documented in 12 of the 14 species of salamanders known to inhabit the former Soviet Union (Table 1). The remaining two species, *Triturus dobrogicus* and *Hynobius turkestanicus,* are poorly known and the latter may now be extinct (Kuzmin 1999, 2013). Declines have been documented in 22 of the 29 species of frogs of the CIS (Table 1). The difference between the two orders may be related to a general evolutionary regression of the Anura (Kuzmin, in press).

Table 1. Amphibian declines within the territory of the Commonwealth of Independent States. From Kuzmin (1994a), with additions.

Species	Regions	Years	Causes of Declines	Sources of Information
Salamandrella keyserlingii	Siberia: upper Angara River	—	A2, A10	Pleshanova (1985)
	Ekaterinburg city	1970s–2000s	A23	Vershinin (1990, 2002)
	Tomsk city	—	A23	Kuranova (1995)
	Far East, Zeya River basin	—	A9	Kolobaev and Tarasov (2000)
Onychodactylus fischeri	Primorye	—	A1	Kuzmin (1995b); Maslova (1998); Kuzmin and Maslova (2003)
Ranodon sibiricus	Junggarian Alatau Ridge	Early 20th century–1990s	A1, A13, A27, A32, N5	Brushko and Narbaeva (1988); Kuzmin *et al*. (1997, 1998); Kuzmin (1994b, 1999); Kuzmin and Thiesmeier (2001)
Salamandra salamandra	Ukrainian Carpathians	1960s–1970s	A1, A24, A25	Polushina (1977); Taraszczuk (1985); Kuzmin (1994b)
Mertensiella caucasica	Georgia	1980s	A18, A19	Kuzmin (1994a); Tarkhnishvili (1995); Tarkhnishvili and Gokhelashvili (1999)
Lissotriton vulgaris	Moscow city and province	1920s–2000s	A11, A12, A14, A21, A23	Bannikov and Isakov (1967); Kuzmin (1989, 1994a); Kuzmin *et al*. (1996); Manteifel *et al*. (1991); Reshetnikov and Manteifel (1997); Reshetnikov (2001, 2003)
	Samara city	1975–1995	A11, A14, A29	Pavlov *et al*. (1995)

Species	Regions	Years	Causes of Declines	Sources of Information
	Volga-Kama region	—	A1	Garanin (1983)
	Lower Volga	1973–1988	A5	Kubantsev and Kolyakin (1988)
	Ukrainian Carpathians	—	A6, A10, A14, A15	Taraszczuk (1985)
	Steppe on the Dnieper River	—	A14, A23	Bobylev (1989); Misyura *et al.* (1995b)
	Yuzhnyi Bug River basin	—	A13	Goncharenko, (1995)
	Ekaterinburg city	1970s–2000s	A23	Vershinin (1990, 2002)
	Tomsk city	—	A23	Kuranova (1995)
	Azerbaijan	—	A8, A10	Alekperov and Jafarova (1981)
	Georgia	—	A11	Tarkhnishvili (1995)
Ommatotriton ophryticus	North Caucasus	1960s–1980s	A7, A10, A13, N1, 2, N3	Tuniyev *et al.* (1986); Kuzmin (1993, 1994b)
	Georgia	—	A10, A11, A13, A14	Janashvili and Zhordaniya (1981); Tarkhnishvili (1995); Tarkhnishvili and Gokhelashvili (1999)
Lissotriton montandoni	Ukrainian Carpathians	1980s	A15, A24, A25	Tatarinov (1977); Taraszczuk (1985); Kuzmin (1993, 1994b); Zabroda (1993)
Ichthyosaura alpestris	Ukrainian Carpathians	1980s	A15, A16, A24, A25	Tatarinov (1977); Taraszczuk (1985); Kuzmin (1993, 1994b); Zabroda (1993)
Triturus cristatus	Moscow city and province	1920s–2000s	A11, A12, A14, A21, A23, N3	Bannikov and Isakov (1967); Kuzmin (1989, 1994a,b); Kuzmin and Bobrov (1995); Kuzmin *et al.* (1996); Manteifel *et al.* (1991); Reshetnikov and Manteifel (1997); Reshetnikov (2001, 2003)
	Lipetskaya Province	1972–1997	A1	Klimov 1999
	Samara city	1975–1995	A11, A14, A29	Pavlov *et al.* (1995)
	Nizhny Novgorod city	1970–1979	A11, A14, A15	Sharygin and Ushakov (1979)
	Volga-Kama region	—	A1	Garanin (1983)
	Ukrainian Carpathians	—	A6, A10, A14, A15	Tatarinov (1977)
	Yuzhnyi Bug River basin	—	A13	Goncharenko (1995)
Triturus dobrogicus	Transcarpathia	—	A21	Litvinchuk and Borkin (2002)

Species	Regions	Years	Causes of Declines	Sources of Information
Triturus karelinii	Transcaucasia	—	A10, A11	Alekperov and Jafarova (1981); Kuzmin (1994b); Tarkhnishvili (1995)
	Sochi Town area	—	A10	Tuniyev (2001)
Bombina bombina	Moscow city and province	1920s–1980s	A10, A11, A23	Bannikov and Isakov (1967); Kuzmin (1989); Kuzmin and Bobrov (1995)
	Samara city	1975–1995	A11, A14, A29	Pavlov *et al.* (1995)
	Nizhny Novgorod city	1970–1979	A11, A14	Sharygin and Ushakov (1979)
	Volga-Kama region	—	A1	Garanin (1983)
	Severskii Donets River	1980–1986	A13	Gogoleva (1987)
	Mordovia	1976–2002	A10, A13	Ruchin (2003)
	Lower Volga	1973–1988	A5	Kubantsev and Kolyakin (1988)
	Steppe on the Dnieper River	—	A14	Bobylev (1989)
	Ukrainian Polesje	—	A10	Zabroda (1988)
	Yuzhnyi Bug River basin	—	A13	Goncharenko (1995)
	Byelorussia		A10	Pikulik (1995)
Bombina variegata	Ukrainian Carpathians	1975–1995	A1, A2, A23	Kuzmin and Scerbanj (1996)
	Georgia	—	A18	Janashvili and Zhordaniya (1981); Tarkhnishvili and Gokhelashvili (1999)
Pelobates fuscus	Moscow city and province	1922–1966	A11, A23	Bannikov and Isakov (1967); Gorbunov (1989); Kuzmin (1989); Kuzmin *et al.* (1996)
	Nizhny Novgorod city	1970–1979	A23	Sharygin and Ushakov 1979
	Lower Volga	1973–1988	A5	Kubantsev and Kolyakin (1988)
	Severskii Donets River	1980–1986	A13	Gogoleva (1987)
	Steppe Area of the Dnieper River	—	A14	Misyura and Noskova (1987)
	Byelorussia	—	A10	Pikulik (1995)
Pelobates syriacus	Georgia and Armenia	—	A10, A13, A14, A28	Egiazarian (1981); Janashvili and Zhordaniya (1981); Tarkhnishvili (1995); Tarkhnishvili and Gokhelashvili (1999)
	Erevan city	—	A12	Serbinova *et al.* (1993)

Species	Regions	Years	Causes of Declines	Sources of Information
Pelodytes caucasicus	North Caucasus	—	A1, A9, A18	Golubev (1984)
Bufo bufo	Moscow	1922–1966	A11, A23	Bannikov and Isakov (1966); Kuzmin, (1989); Kuzmin *et al.* (1996)
	Voronezh	1950–1970	A1	Garanin (1983)
	Nizhny Novgorod city	1970–1979	A1, A23	Sharygin and Ushakov (1979)
	Volga-Kama region	—	A1	Garanin (1983)
	Mordovia	—	A1, A10	Ruchin 2003
	Novosibirsk	1939–1969	—	Telegin (1971)
	Altai Mountains	1980s	A22	Yakovlev (1990)
	Baikal region	1960–1970	A1, A4	Shvetsov (1984)
	steppe on the Dnieper and Dniester rivers	—	A1, A5, A14, A28, A31	Konstantinova (1981); Taraszczuk (1987); Bobylev (1989); Misyura *et al.* (1995a)
	Yuzhnyi Bug River basin	—	A5	Goncharenko (1995)
Bufo verrucosissimus	Novorossiisk District	—	—	Leontyeva and Pereshkolnik (1995)
Bufo viridis	Moscow city and province	1922–2000s	A10, A11, A14, A23	Bannikov and Isakov (1967); Kuzmin (1989, 1994a); Kuzmin *et al.* (1996); Murkina (1989)
	Nizhny Novgorod city	1970–1979	A23	Sharygin and Ushakov (1979)
	steppe on the Dnieper River	—	A14	Bobylev (1989)
	Severskii Donets River	1980–1986	A4	Gogoleva (1987)
	Lower Volga	1973–1988	A5	Kubantsev and Kolyakin (1988)
	Tbilisi	—	A2, A6	Khodzhevanishvili and Bakradze (1990)
Bufo calamita	Western Ukraine	—	—	Misyura *et al.* (1995b)
Hyla orientalis	Central Chernozyom region	until 1980s	N5	Lada and Sokolov (1995)
	steppe on the Dnieper River	—	A5	Konstantinova (1981); Bobylev (1989)
Hyla arborea	Ukrainian Carpathians	—	A1	Polushina (1977)

Species	Regions	Years	Causes of Declines	Sources of Information
Hyla japonica	Far East, Zeya River basin	—	A17	Ilyashenko (1984); Kolobaev and Tarasov (2000)
Rana temporaria	Moscow city and province	1922–2000s	A1, A6, A7, A11, A14, A21, A23, A28, N4	Bannikov and Isakov (1967); Kuzmin (1989); Kuzmin *et al.* (1996); Murkina (1989); Lyapkov (2001); Reshetnikov (2001)
	Nizhny Novgorod area	—	A1	Lebedinsky (1995)
	steppe on the Dnieper River	—	A14	Bobylev (1989); Misyura *et al.* (1995a)
	Ekaterinburg city	1970s–2000s	A23	Vershinin (1990, 2002)
Rana arvalis	Moscow city and province	1922–2000s	A1, A6, A7, A11, A14, A23, A28, N4	Bannikov and Isakov (1967); Kuzmin (1989); Kuzmin *et al.* (1996); Murkina (1989); Lyapkov (2001)
	Severskii Donets River	1980–1986	A4	Gogoleva (1987)
	Volga-Kama region	1953–1963	N5	Garanin (1964)
	Lower Volga	1973–1988	A5	Kubantsev and Kolyakin (1988)
	Nizhny Novgorod area	—	A1	Lebedinsky (1995)
	Ekaterinburg city	1970s–2000s	A23	Vershinin (1990, 2002)
	Tomsk city and province	—	A10, A23, A30	Kuranova (1981, 1995)
	Novosibirsk	1939–1969	–	Telegin (1971)
	Altai Mountains	1980s	A22	Yakovlev (1990)
Rana dalmatina	Ukrainian Carpathians	—	A1, A5, A6	Misyura *et al.* (1995b)
Rana macrocnemis	Kopetdagh Ridge	—	A1	Ataeva (1981); Kuzmin (1999)
	Novorossiisk District	—	—	Leontyeva and Pereshkolnik (1995)
Rana asiatica	Kazakhstan	1960s–1990s	A10, A30, A32	Brushko (1988); Kuzmin (1994a, 1999)
Rana amurensis	Tomskaya Province	1970s	A30	Kuranova (2001)
	Buryatia	1966–1971	A10, N5	Khabaeva (1972)
	Far East, Zeya River basin	1974–1990	A30	Kolobaev and Tarasov (2000)
	Khabarovskii Region	1990s	A32	Adnagulov (2000)

Species	Regions	Years	Causes of Declines	Sources of Information
Rana dybowskii	Far East, Zeya River basin	1974–1990	A30	Kolobaev (2000); Kolobaev and Tarasov (2000)
	Primorye	1990s–2000s	A32	Kuzmin and Maslova (2003)
	Khabarovskii Region	1990s	A32	Adnagulov (2000)
Rana pirica	Sakhalin	—	A14, A15	Flax (1991)
Pelophylax lessonae / esculentus	Moscow	1920s–1980s	A11, A14, A23, N3, N4	Bannikov and Isakov (1967); Kuzmin (1989); Kuzmin and Bobrov (1995); Kuzmin *et al.* (1996)
	steppe on the Dnieper River	—	A14	Bobylev (1989)
	Yuzhnyi Bug River basin	—	A13	Goncharenko (1995)
	Ukrainian Carpathians	—	A10	Zabroda (1988)
Pelophylax ridibundus	Moscow	1920s–1990s	A11, A14, A20	Bannikov and Isakov (1967); Kuzmin (1989); Kuzmin (1994a); Kuzmin *et al.* (1996)
	Lower Volga	1973–1988	A5	Kubantsev and Kolyakin (1988)
	Krasnodar city	1968–1983	A11	Zhukova (1988)
	Ukrainian Polesje	—	A10	Zabroda (1988)
	Yuzhnyi Bug River basin	—	A13	Goncharenko (1995)
	Chu River	—	A25, A26	Umrikhina (1984)
Pelophylax nigromaculatus	Khabarovskii Region	1990–2000	—	Tagirova (2001)
	Khabarovskii Region	1990s	A32	Adnagulov (2000)

Dashes indicate that data are unavailable.

Causes of declines:

A = Anthropogenic Factors: 1. Destruction of forests and other arboreal vegetation; 2. Destruction of hiding places; 3. Stream-bank damage by cattle; 4. Intensive cattle pasturage; 5. Intensive use of artificial fertilizers and pesticides in agriculture; 6. Use of pesticides; 7. Use of fertilizers; 8. Removal of rice fields; 9. Earthwork; 10. Pond drainage; 11. Pond destruction; 12. Pond clearing and construction of embankments; 13. Water pollution by cattle; 14. Industrial pollution of water; 15. Pollution of water by domestic wastes; 16. Transportation of logs by heavy trucks; 17. Floods; 18. Pollution and drying of streams; 19. Skidding of cut timber along streams; 20. River-bank clearing and construction of embankments; 21. Introduction of the fish *Perccottus glenii*; 22. Introduction of *Pelophylax ridibundus*; 23. Urbanization; 24. Collecting for commercial purposes; 25. Collecting for educational purposes; 26. Collecting for scientific purposes; 27. Fishing; 28. Intensive recreation; 29. Wanton killing by people; 30. Construction of large reservoirs; 31. Plowing of riparian habitats; 32. Collecting for purposes of traditional medicine.

N = Natural Factors: 1. Mud filling in ponds; 2. Partial drying of ponds; 3. Increase in water eutrophication; 4. Overgrown with vegetation and decrease in water depth in ponds; 5. Probable increase of temperature and decrease in humidity.

Most reports of declines involve widespread and generally abundant species. Among them, *Triturus cristatus*, *Bombina bombina*, *Hyla orientalis*, *Bufo bufo*, and *Rana temporaria* have had the most significant declines, especially at the periphery of their ranges. These species are among the lineages most susceptible to anthropogenic influences in urbanized and industrial regions such as central Russia and Ukraine. Nevertheless, populations of these species seem to be relatively secure in large areas of natural landscapes so their future seems reasonably good. Even declines of endemic and relict species (such as *Onychodactylus fischeri*, *Ranodon sibiricus*, *Mertensiella caucasica*, *Ommatotriton ophryticus*, *Lissotriton montandoni*, *T. karelini*, *Ichthyosaura alpestris*, *Pelodytes caucasicus*, and *P. syriacus*) are rarely reported and are probably localized in extent. Nevertheless, such declines may have severe consequences because of the small population sizes and sometimes-limited distribution of these species.

Among the newts and related genera, *Triturus cristatus* has declined more rapidly than has the phylogenetically related *Lissotriton vulgaris*, probably because the genetic constitution and larval adaptations of the former make it more sensitive than the latter (Kuzmin, in press). *T. cristatus* has declined in many regions: Belarus (Kuzmin *et al*. 1995), Tataria (Garanin and Ushakov 1969, 1970), Nizhegorodskaya (Sharygin and Ushakov 1979; Lebedinsky 1981), Kharkovskaya (Shidlovsky and Kotov 1916; Krivitskii *et al*. 1986), Lvovskaya (Tatarinov 1977), Moskovskaya (Bobrov *et al*. 1995; Kuzmin and Bobrov 1995; Kuzmin 2001), and in the provinces of Kurskaya, Belgorodskaya, Lipetskaya, and Tambovskaya (Lada and Sokolov 1995). Declines have been documented in only approximately 16% of the region of the CIS inhabited by *T. cristatus*, especially in Russia, Ukraine, and in some of the former republics (Kuzmin 2001). These regions comprise less than half of the species' total range. Even within some of these areas *T. cristatus* is not a rare animal.

B. Time-Frame and Regions Affected

Most data on amphibian declines are from the 1970s to the 2000s and largely result from the increased interest in nature conservation during this period. At the same time, there has been an increase in anthropogenic influences on amphibian populations in the past three to four decades. Declines in the 1920s and 1940s were connected primarily to the destruction and alteration of habitats because of urbanization, industrialization, and establishment of collective farms, and as a consequence of World War II (Bannikov and Isakov 1967; Beskrovnyi and Burmenskaya 1970). Recognition of a decline does not imply, however, that the decline began close to the time it was recognized. For example, the relative rarity of *Triturus cristatus* in European Russia is often claimed to be of recent occurrence. An analysis of the older literature suggests that this species was rare at least a century ago (Kuzmin 2001).

Most amphibian declines within the CIS have been observed in the European region of this vast territory (Table 1). This situation likely reflects the better state of knowledge of amphibian populations in the western regions of the CIS than in the central, eastern, and southern areas, as well as the fact that the western regions have the greatest number of threats to amphibian populations. There are fewer reports of amphibian declines from western Siberia and the Far East, although these regions have been studied to a reasonable extent.

C. Natural Factors

Amphibian declines as a result of natural factors (see Table 1) are rarely reported and involve few amphibian species. Natural succession leading to eutrophication and overgrowth of the breeding ponds, making them unsuitable for many amphibian species, is the primary cause of concern. Succession is especially harmful in anthropogenic landscapes where amphibian populations are highly fragmented and often isolated. Combined with anthropogenic factors, the natural succession of a pond community has led to local extirpation of some species. Increasing aridity, often accompanied by an increase in temperature, is another threat that seems to be responsible for amphibian declines. Changes in rainfall patterns operate on a long-term basis and embrace large areas. This factor seems to be most important in the declines of *Ranodon sibiricus* and *Hyla orientalis*. Large-scale changes in climate and corresponding changes in temperature and humidity at local levels may also have an impact on amphibian species but these influences have been insufficiently studied.

D. Anthropogenic Factors

Anthropogenic factors are probably the main causes of recent declines of amphibians throughout the CIS (Kuzmin 1994a,b, 1995a). The destruction of forests and other arboreal vegetation has been the most widespread type of habitat change. Deforestation has led both to the destruction and severe alteration of terrestrial habitats and to the drying of breeding ponds and streams. Deforestation was identified as the cause of decline in a large majority of the species studied. Forest species, such as newts, common toads, and taxa from high elevations specialized for stream life, are most harmed by deforestation. For example, cutting trees and skidding logs along mountain streams led to the almost total extirpation of some Georgian populations of *Mertensiella caucasica* (Kuzmin 1994c).

In contrast, transportation of timber by heavy trucks in the Carpathian Mountains led to the formation of deep ruts in the road that created suitable breeding sites for newts. Although newts are attracted by these newly established bodies of water and breed in them, the eggs and larvae of species such as *Lissotriton montandoni* and *Ichthyosaura alpestris* are killed by subsequent traffic and the rapid drying of the ruts. As a result, populations near the roads have declined markedly (Taraszczuk 1985). Although the overall amphibian mortality on roads may be high, the influence of logging roads in regional population declines is unclear (Ganeev *et al*, 1985; Ryzhevich 1989).

The formation of forest roads has led in some instances to their use as dispersal corridors for amphibians within the forest complex. Tree-felling and rural road-building in forests can result in the formation of a mosaic of small artificial ponds that promote an ability to disperse and a localized increase in abundance. This phenomenon has been observed to affect populations of *Salamandrella keyserlingii*, *Pelobates fuscus*, *Bufo bufo*, *B. viridis*, *Rana temporaria*, and *R. arvalis* (Polushina 1977; Pikulik 1985; Kutenkov 1990; Kuzmin 1994c, 1999; Guseva 1995) in Karelia, Moskovskaya Province, the Ural Mountains, Belarus, and in the Carpathians.

The creation of artificial bodies of water, such as fish ponds, channels, sedimentation reservoirs, and mitigation ditches, has promoted population increases in *Salamandrella keyserlingii*, *Lissotriton vulgaris*, *Ommatotriton ophryticus*, *Bombina bombina*, *Pelobates fuscus*, *Bufo bufo*, *Hyla orientalis*, *Rana arvalis*, *R. temporaria*, *P. ridibundus*, and *P. lessonae/esculentus* (Toporkova 1977; Kubantsev and Zhukova 1981; Kireev 1983; Ilyashenko 1984; Tuniyev *et al*. 1986; Gogoleva 1987; Taraszczuk 1987; Kutenkov 1990; Kuzmin 1999). The use of artificial bodies of water as amphibian breeding sites has been observed not only in the forested areas of the European part of the CIS, but also in the non-forested areas of southern Russia, Kalmykia, and Precaucasia, and in the steppes of Ukraine. Species that are tolerant of pollution and changes in the landscape caused by humans sometimes form populations in the agricultural landscape that are larger than populations in native habitats. Such common, widespread species as *Bufo viridis* and *Pelophylax ridibundus* are good examples of species actually increasing despite human activities. Surprisingly, *Bufo calamita*, a rare species, also seems to prefer human neighbourhoods in some instances; more than 50% of its recorded distribution in Belarus was in or near farmlands (Pikulik 1995).

Wetland drainage is the second most important factor affecting the status of amphibians within the CIS. As in terrestrial ecosystems, wetland drainage not only destroys critical breeding habitat, but also results in the fragmentation and isolation of the remaining populations. Coupled with direct habitat loss, the intensive use of artificial fertilizers and pesticides is also very important, especially in the vicinity of wetland breeding sites. Contaminants and toxic chemicals degrade water quality. In the CIS, they often result from livestock ranching (especially cattle) and farming, and from industrial wastes. The last appears to be more harmful to amphibians because it causes profound changes in physiology and biochemistry and results in populations being in a constant state of change during adaptation to contaminated conditions (Misyura *et al*. 1996). There are different types of changes that affect amphibians in polluted habitats. Adaptive changes may ensure amphibian survival in polluted environments and may provide the basis for microevolution under these conditions, whereas pathological changes only result in population declines or extirpation (Peskova 2001, 2002).

Other anthropogenic factors seem to be less important in amphibian declines within the CIS, and concern relatively few amphibian species. Thermal pollution as a result of human activities has actually promoted the expansion of the frog *Pelophylax ridibundus* (see above). Urbanization is the most important of the detrimental anthropogenic causes of declining status because it affects many species (to varying degrees) and because it