PREFACE

This book presents current research in the study of reptiles from across the globe. Topics discussed include the Northern Pine Snake; the Crocodilian cardiovascular system; spatial cognition in reptiles; the organization and expression of immunoglobulin isotypes in reptiles; conservation of reptiles; salmonella infection in reptiles and advances in amphibian and reptile ecotoxicological research.

Chapter 1 - At the northern limit of their range, the Pine Snake (*Pituophis melanoleucus*) is listed as a threatened species by the state of New Jersey. They occur in the southern portion of the state in an area known as the Pine Barrens, where they are isolated from other conspecifics much farther south in Tennessee, Virginia, Kentucky and the Carolinas. The major threat that Pine Snakes face throughout their range is habitat loss. Pine Snakes excavate long nest tunnels and lay their eggs underground. In the fall they dig or modify abandoned mammal burrows or stump-holes as hibernation sites where they survive the winter. Because they are at the northern limit of their range, females select open sandy areas in the forest with complete sun penetration to the underground nest. Shaded areas with trees or shrubs could cause eggs to incubate at lower temperature limits in the nest and cause hatchlings to be behaviorally impaired. Their nesting behavior in open fields renders them vulnerable not only to predators, but to human poachers and off-road vehicles that can run over females within nesting tunnels, destroy the nests, or crush and kill eggs or hatchlings. Poaching of eggs and adults during the nesting season, or at other times of the summer, is a severe threat to Pine Snakes. Other threats include loss of nesting and hibernation sites, fragmentation of important foraging habitat, enhanced predation from human commensals (dogs and cats), and natural predators whose populations have increased due to the presence of humans (Coyote [*Canus latrans*], Fox [*Vulpes fulva*], Raccoon [*Procyon lotor*] and Skunk [*Mephitis mephitis*]). Properly planned research and intensive long-term studies have proven not to cause disruptions to Pine Snake ecology or behavior. Because New Jersey Pine Snakes have a distinct black and white pattern not found in this species from elsewhere in their range, they are highly prized by collectors. Measures to protect Pine Snakes are discussed, particularly habitat protection, enhancement of known nesting areas, construction of hibernacula, and protection of nesting and hibernation habitats from off-road vehicles. An extensive conservation and educational campaign is needed to raise public awareness about the harmless Pine Snake, the important role they play in the food chain in the Pine Barrens ecosystem, and to develop ways to protect and enhance their population and habitat.

Chapter 2 - Crocodilians comprise 23 extant species within three Families, Crocodylidae, Alligatoridae and Gavialidae, which are more closely related to endothermic birds and extinct Dinosaurs than to the rest of the ectothermic reptiles - Lepidosaurs and Testudines. Crocodilians posses a unique vertebrate cardiac anatomy - two systemic aortae like all reptiles, and a completely four-chambered heart with two atria and two ventricles, similar to birds and mammals. All reptiles are capable of right-to-left cardiac shunt (R-L shunt), and reptiles regularly bypass the lungs and recirculate systemic blood (R-L shunt). In the past 50 years, it has become a tenet in comparative physiology that R-L shunt may provide adaptive advantage(s) to reptiles, for example, by allowing for prolonged submergence (longer aquatic dives).

The four-chambered crocodilian heart allows for elimination of R-L shunt by surgical occlusion of the aorta (Left Aorta – LAo) that allows for R-L shunt, a procedure not possible in other reptiles. Recent studies have investigated the significance of R-L shunt in American alligator (*Alligator mississippiensis*) by surgically occluding the LAo and measuring growth, metabolism, digestion and respiration. Three variables were affected that suggest shunt may be important for digestion - secretion of gastric acid together with rate of bone demineralization, and body mass during early ontogenetic growth in a separate study. However, the following variables were not adversely affected by occluding the LAo in alligators - head and snout-to-vent lengths during early ontogenetic growth, oxygen consumption of juveniles and eggs, voluntary apnoea time, breathing frequency, tidal volume and minute ventilation. These unaffected variables support the hypothesis that the crocodilian cardiovascular system is not an adaptive circulatory "design", but a plesiomorphic character state not selected against.

However, the crocodilian oxygen transport system is quite plastic in response to repeated bouts of exercise, unlike the metabolically inflexible, 'classic reptilian' response. Cardiovascular and metabolic responses to exercise training have been investigated for two species, American alligator and Estuarine crocodile (*Crocodylus porosus*). Exercise-trained crocodiles and alligators showed an increase in maximum oxygen consumption compared to sedentary control animals. In addition, exercise-trained alligators demonstrated a significant increase in ventricular mass, possibly a hypertrophy associated with the increased aerobic capacity. However, similar to previously studied reptiles, aerobic and anaerobic enzymatic activities did not change in response to exercise training. The response of crocodilians to repeated bouts of activity appears to be intermediate between a 'classic' mammalian training response and the 'metabolically inflexible' training response of other reptiles.

Chapter 3 - Spatial cognition is considered an essential survival tool for almost all species as it allows an animal to navigate through complex natural environments. This skill is necessary to efficiently access food, water and shelter. While comparably little is known about the processes underlying navigational behavior in reptiles, the cognitive processes underlying orientation in mammals and birds are relatively well understood. This chapter reviews the available literature on spatial cognition in a range of reptile species. It attempts to link research from both laboratory and field settings and interprets the evidence in terms of the behavioural ecology and evolutionary history of the specific species. Finally we discuss the brain processes which underlie spatial navigation in reptiles in light of what is known about this ability in mammals and birds.

Chapter 4 - Immunoglobulins (antibodies) are the key components of the adaptive immune system in jawed vertebrates including elasmobranches, teleosts, amphibians, reptiles,

birds, and mammals. The canonical immunoglobulin molecules are composed of two identical heavy chains and two identical light chains. Both the heavy and light chains consist of a variable domain and a constant region. Except reptiles, the structure and organization of immunoglobulin loci from different vertebrate classes are extensively investigated. In considering the great diversity of reptilian species, it is important to recognize the information regarding the structure of immunoglobulin loci and the development of immunoglobulin repertoire in reptiles. The recent description of the genomic organization of immunoglobulin heavy and light chain loci from the green anole lizard (*Anolis carolinensis*) has greatly facilitated our understanding about structural and functional characteristics of reptilian immunoglobulins as well as the evolutionary dynamics of immunoglobulin genes in tetrapods. In this chapter the authors summarize our current knowledge of the organization and expression of immunoglobulin isotypes in reptiles and also discuss the evolutionary genomics of reptilian immunoglobulin heavy and light chain multigene families as compared to their homologs in other vertebrates.

Chapter 5 - General factors are outlined that may influence the support of members of the public for the conservation of different species of reptiles. Survey results are then summarised of the variations in the likeability of different species of reptiles as well as whether or not their survival is supported by those surveyed. The relationship between these two factors is outlined and its consequences for the survival of reptile species compared to birds and mammals is specified, assuming a decision situation like that depicted by the Noah's Ark problem. Furthermore, the extent to which the results support the similarity principle are considered. A substantial dichotomy in the likeability of different reptile species is observed: turtle species tend to be liked much more than species of crocodiles and snakes. This requires some modification to the similarity principle. This disparity is reflected in a dichotomy in public policies for the conservation of reptiles. Evidence in favour of this hypothesis is outlined and the hypothesis is illustrated by Australian policies for the consideration of reptiles. Some attention is also given to the changes in attitudes towards the conservation of reptiles that can occur as a result of knowledge provision and ecotourism.

Chapter 6 - There is a popular question as to whether dinosaurs and reptiles are different or similar. It seems to be a basic and interesting topic in reptile biology and paleobiology. In order to answer this question, the present chapter compares these two species.

The earliest reptiles are known from the early Pennsylvanian (323–317 million years ago), and the amniote egg evolved in the earliest reptiles. This allowed for the first true occupation of the land by tetrapods. The term "archosaur" had come to include crocodiles, dinosaurs, and a wide variety of primitive Triassic reptiles. The continuity of meaning is intended to prevent confusion about what the term "dinosaur" means. There is a wide consensus among paleontologists that birds are the descendants of theropod dinosaurs. The skeletal structures of saurischian dinosaurs are interpreted as osteological correlates of air sacs and pneumatic diverticula similar to that of birds, but no evidence of air-sac respiration has been found in ornithischian dinosaurs. The pelvis in the saurischian dinosaurs resembles that of still-extant reptiles, but in the ornithischian dinosaurs the pubic bone of the pelvis has forward and backward extensions that resemble those found in birds.

That is, it is possible to consider that modern birds are extant dinosaurs, and it is also possible to recognize dinosaurs as a group of extinct reptiles. In conclusion, it is not logical to classify all dinosaurs in a single order; therefore, two types of dinosaur should be at least distinguished by respiratory and structural differences.

Chapter 7 - Recent discoveries of dinosaur localities in high-latitude (polar) regions and the necessity of understanding the reasons why these prehistoric animals lived there in severe climatic conditions have aroused considerable interest in them [6, 9]. As noted by L. A. Nesov [6, p. 51], "neither the hypothesis of migratory hadrosaurs nor that of their permanent residence in high-latitude areas can adequately explain how the process of incubating eggs occurred and how the adult and young dinosaurs passed the winter in northeast Russia". In the Late Mesozoic, the territory of present-day Teete was located somewhat north of 60° N in a polar region [9]. The dinosaur localities in northern Alaska also had a similarly high-latitude position. There the average annual temperature ranged in the Late Cretaceous from a maximum +13°C to a minimum +2° [9]. In the Neocomian, the average annual temperature in the Arctic basin did not exceed +15°C [1]. This paper presents new factual material obtained from Teete, which suggests that in the Early Cretaceous (Berriasian-Barremian-Neocomian) armored ankylosaurs inhabited this locality (a polar region). The Teete (photo 1) locality represents outcrops extending laterally along the right bank of Teete Creek flowing from west to east. From bottom to top, the cross-section includes:

Chapter 8 - Cadmium is a persistent contaminant accumulated in the environment from both anthropogenic and natural sources. Every year, large quantities of this metal are released in the different environmental compartments and may pose a significant threat to the biota exposed. Intracellular damage caused by cadmium exposure includes protein denaturation, lipid peroxidation, generation of reactive oxygen species and DNA strand breaks. Many studies have also demonstrated that this ion has a teratogenic or lethal effect on embryos, related to the dose and exposure time. In spite of the wide number of studies carried out in laboratory mammals, data on cadmium effects on fertility, reproduction and embryonic development of wild terrestrial vertebrates are still limited. In particular, information on the consequences of environmental cadmium exposure on reptiles survival and biodiversity are particularly scanty. Reptiles are presently considered highly susceptible to a number of environmental pollutants and this has contributed to the global decline of several wild populations of turtles, crocodilians and lizards. As regarding cadmium effects on offspring survival, reptiles eggs for a long time have been considered well protect from the external environment and the presence of environmental contaminants in eggs or developing embryos has been attributed to a maternal transference during vitellogenesis and oviductal egg retention. More recently, it has been demonstrate that metal ions and organic contaminants present in soil may cross the flexible parchment-like shell of reptilian eggs. In consideration of the few data currently available the authors decided to investigate cadmium effects on biological processes such as reproduction and development in the reptile *Podarcis sicula*, a lizard species inhabiting both pristine and urbanized areas. The results summarized in this chapter clearly demonstrate that cadmium can interfere with the welfare and the reproductive fitness of adults, and with the development and survival of embryos. In turn, these detrimental effects on offspring production may dramatically modify the survival of wild populations inhabiting contaminated areas significantly endangering the local biodiversity and the ecological equilibrium.

Chapter 9 - There is a lack of systemic evaluation of *Salmonella* in herpetofauna (amphibians and reptiles). Because of this, we still debate whether or not *Salmonella* is a natural member of their micro-flora. Regardless of its origin, herpetofauna are known carriers and potential source of infection to humans. Thus, the extent of its incidence warrants investigation. This review briefly summarizes these studies, with emphasis on more recent

additions to the literature. Most attention will be directed towards proposing novel future directions of herpetofaunal *Salmonella* research – mainly under a conservation framework. For instance, anthropogenic alterations to habitats have been increasing in recent years. These alterations have the potential to act as stressors upon inhabitants. This suite of stressors is generally accepted as the cause of global herpetofaunal declines (particularly amphibians). These stressors are also altering the micro-communities associated with and within inhabitants. No studies have examined *Salmonella* infection changes in herpetofauna as a result of stress. Studies addressing changes in herpetofaunal *Salmonella* disease dynamics due to stress in altered habitats could provide useful data for disease ecologists, microbiologists, physiologists, and herpetologists alike.

Chapter 10 - Over the past three decades, considerable advances in ecotoxicology have been accomplished in many groups of organisms. However, amphibians and reptiles have been traditionally at the tail end of vertebrates with respect to ecotoxicological research. Both groups, but specially amphibians, are among the most affected by the global biodiversity crisis, and chemical pollution is nowadays assumed to be an important problem for perpetuation of these animals.

Many scientists have suggested that a higher level of integration between ecology and toxicology would be desirable in order to gain a better understanding of the real impact of pollution on wildlife. Nevertheless, ecotoxicology of amphibians and reptiles has today reached an acceptable status of development and integration if we compare it to what was known a couple of decades ago, when the idea of the global decline of biodiversity was still in its embryonic stage.

In this chapter, the authors try to illustrate how amphibian and reptile ecotoxicological studies have evolved since the simple laboratory assays with little ecological relevance and focused on a few well-known species, to today's more complex studies carried out under an ecological perspective that include a huge taxonomic spectrum.

The authors have conducted a review of scientific literature on herp ecotoxicology through the analysis of the most relevant bibliographic sources. The authors have assessed how ecotoxicology of amphibians and reptiles has changed in its aims from several points of view, including taxonomy, geography, sources of pollution, endpoints, complexity and ecological relevance.

The results illustrate the evolution of this branch of science, as well as the arising of some pending matters that should be addressed in the future.