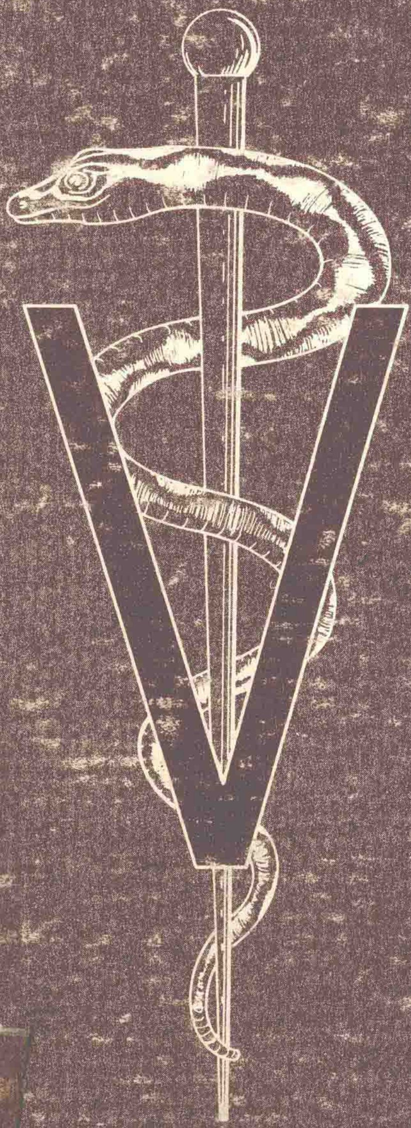
Veterinary Biology and Medicine of Captive Amphibians and Reptiles



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To my father, Edward G. Marcus, who initiated and inspired my interest in biological science with walks in a city park before I was five years old.

Preface

From prehistoric time, people have held snakes and, to a lesser extent, other reptiles and amphibians in fear and awe. The serpent's role in the Garden of Eden, the deification of crocodiles by ancient Egyptians, and the legend, told by some American Indians, that the world rested on the back of a tortoise are some examples of the reptile's place in folklore and religion. The Asian snake charmer, the Hopi Indian dancing with rattlesnakes held in hands and mouth, and religious cults using or worshiping reptiles and amphibians have persisted to modern times.

An extension of this fascination with herpetofauna (reptiles and amphibians) is the practice of keeping these creatures as pets. This book is directed at the private veterinary practitioner who must advise people about the care of these pets and who must diagnose and treat these animals. Veterinary students should also find this text useful as a reference source.

Certain herpetofauna, especially newts, frogs, and turtles, are often used as laboratory animals. Problems in these laboratory colonies often occur epizootically. The housing, management, and facilities for laboratory animals are markedly different than for individual pets. There are even more variables in zoo medicine, where there is a greater variety and number of species and problems related to public display. Therefore, some of the advice offered in this book concerning individual pets may not be applicable to laboratory animal colonies or zoos.

In a similar vein, herpetologists, veterinary pathologists, and other biomedical scientists should find the text selectively useful as a reference source. However, I hope it will be judged primarily by how well it addresses the principal intended audience, the veterinary practitioner.

I want to express one other thought about what this book is not. It is not intended to encourage the indiscriminate keeping of reptiles and amphibians. I particularly disparage the keeping of endangered species, animals that do not thrive well in captivity, or dangerous animals, such as poisonous snakes. I am sure most veterinarians will agree with this sentiment. However, once faced with the problem of dealing with a sick pet, regardless of how appropriate or desirable that pet may be, most veterinarians would rather be able to offer some useful professional assistance, within reasonable limits of safety, than reject the case completely. I hope this book adequately provides the background and detailed information needed in the veterinary care of reptilian and amphibian pets.

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1 The Normal Amphibian and Reptile

INTRODUCTION

Although it is not possible to give exact figures, reptiles and amphibians are kept as pets in many American homes. It was estimated that 7 million turtles were raised for sale annually in the United States[6] prior to a ban on sale of baby turtles to prevent zoonotic salmonellosis (Chap. 3). Considering the number of iguanas, snakes, caimans, and American chameleons (or anole lizards) sold by pet stores, mail order supply houses, fairs, and circuses, the population of reptilian pets is considerable. According to figures released by the United States Department of Interior, 572,670 amphibians and 2,109,571 reptiles were imported into the United States in 1970. The great majority of these were intended for sale as pets, the rest for display in zoos or for laboratory use. The figures do not reveal how many of these animals survived long enough to be sold for their intended use. Mortality in shipment of these animals is very high owing to overcrowding, filthy conditions, deprivation of food and water, and exposure to the elements.

Psychiatrists may invoke such Freudian concepts as counterphobia and phallic symbolism to explain keeping reptilian pets, but there are more mundane reasons for this practice. Reptiles and amphibians can be interesting and practical pets, even if they lack the affection and intelligence of a dog or cat. They are clean, most of them are quiet, and they can be kept in a relatively small space, an important consideration for apartment dwellers. A boa constrictor can be an attractive conversation piece, and, even if it is not overly affectionate, it can give its owner a cozy hug. In addition, few other pets can be left untended in a cage while the owner leaves for a one- or two-week vacation. It is also advantageous that these animals are hypoallergenic.

As with any other pet, a reptile or amphibian should not be kept unless the owner is willing to take care of it. Most reptilian and amphibian pets are bought or captured by people who, though well-meaning, know little about their biology or care. As a result of improper husbandry, very few of these cold-blooded pets reach maturity. Another problem is that catching large numbers of any given species could decimate natural populations and result in a tilting of balances in nature. Indiscriminate release of unwanted pets in non-indigenous areas could also disrupt the environment.

Various species of sea turtles have been killed for food and their nesting habitats disrupted to the point where they are threatened with extinction. Baby sea turtles are occasionally kept as pets in saltwater aquariums. Since it is impossible to raise them to maturity in a house, keeping them should be discouraged unless the owner intends to release them within their natural range and habitat. Likewise, many crocodilian species are faced with extinction because of excess hunting and habitat destruction. These animals should not be kept as pets because they will not mature and reproduce in household captivity. The current fashion craze for reptilian skins may threaten other species with extinction. The International Union for Conservation of Nature lists 27 species of amphibians and 87 species of reptiles threatened with extinction (as of September, 1970). These should be held captive only by those licensed and qualified to do so.

Even the leopard frog *(Rana pipiens)*,* which we have taken for granted as a readily available laboratory animal, has declined in numbers at an alarming rate. There was an estimated 50% decrease in the United States frog population during the 1960s, mostly owing to destruction of habitat through drainage and construction and pollution of the environment with sewage and chemicals.[49] The annual harvesting of millions of frogs for laboratory use has also taken its toll.

A medium-sized leopard frog eats four grams of insects per day and the tadpoles consume a significant amount of detritus in fresh water.[49] The frogs and tadpoles are eaten by larger predators and thus form an important link in the food chain. Decimation of the frog population could well have ecological effects that may not be appreciated for many years, and then it may be too late to restore the balance.

The limited availability of frogs has caused one biological supply house to plea that fetal pigs be used for vertebrate anatomy courses. This laudable effort deserves acclaim because it reflects a concern and sense of responsibility too infrequently seen in the business world.*

Dangerous species, such as large crocodilians, snapping turtles, and poisonous snakes, should not be household items. Certainly, any veterinarian would be justified in refusing to handle a dangerous animal. Selection of appropriate reptilian pets is discussed by Evans,[41]

*The classification of leopard frogs has been revised. Animals that formerly were considered different geographic races of *R. pipiens* are now designated as different species *(R. pipiens, R. utricularia, R. berlandieri, R. blairi)*. Because this new designation is not widely recognized yet, the leopard frog is referred to as "*R. pipiens*" throughout this text. Reference to this revised classification and information on the commercial availability of leopard frogs and other amphibians can be found in Nace, G. W. and Rosen, J. K.: Sources of amphibians for research II. Herpetol. Rev., *10*:8–15, 1979.

*From Ann Arbor Biological Center, Catalog No. 101, 1976, p. 100.

and the precautions and husbandry techniques used in maintaining poisonous snakes in a serpentarium laboratory are discussed by Softly and Cockett.[83]

Serious amateur herpetologists study their interest with enthusiasm and intelligence and keep careful records on the health and activity of their specimens. Many large cities in the United States have herpetology clubs to which amateur and professional biologists belong. They are always pleased to find someone who is interested and competent to provide veterinary care.

Relatively little information about poikilothermic diseases is found in the curriculum of most veterinary schools or in the veterinary literature. Although some information can be found in books and journals devoted to laboratory animals, much of the pertinent information on diseases in reptilian and amphibian pets is found in the professional journals and amateur bulletins of herpetology, sources unfamiliar to most veterinarians.

Much of the published data on diseases of herpetofauna is based on clinical observation, rarely supported by adequate laboratory studies. Controlled scientific experiments of statistical validity are as rare as turtle's teeth. Thus, one is presented with a small mass of empirical data, much of it probably valid, but for the most part, unproven.

There is no less variation in the spectrum of diseases among cold-blooded hosts than there is among birds and mammals. Studies of species variation are so poor, however, that one must often be satisfied with enunciating principles of therapy for all lizards, all frogs, all snakes, or even all reptiles and amphibians, as if they were one homogeneous group.

Knowledge of reptilian and amphibian disease has suffered not only from lack of trained personnel, but also from lack of funds for research. These animals, with few exceptions (e.g., species used for leather or human food), do not have enough inherent fiscal value to warrant grant support. Even if their diseases could be used as models for higher species, it is usually more appropriate to study disease in homeothermic animals. This is particularly true if one's objectives are in applied, rather than basic, science.

Finances also hinder clinical studies. How thorough (and, therefore, how expensive) a work-up and therapy will the owner of a fifty-cent turtle support? People do keep some very rare and valuable specimens, however, that are economically worth as much study as would be invested in comparably priced livestock. These economic considerations limit what a practitioner can do in a practical way, and they are largely responsible for limitations of knowledge in the field. Nevertheless, I hope veterinarians will investigate reptilian and amphibian pathology further and perform and report controlled experiments whenever possible.

Reptilian and amphibian anatomy, physiology, and pathology differ enough from mammalian and avian forms that some review of these differences is in order. This may seem far removed from the bread-and-butter of practice, but some basic knowledge of structure and function in these animals is necessary if one is to handle their disease processes intelligently. It is also important to have some knowledge of the classification of reptiles and amphibians in order to understand their similarities and differences, and the diversity within the two classes.

PHYLOGENETICS

Amphibians and reptiles, which collectively can be referred to as **herpetofauna,** are uniquely important links in the evolutionary chain. The Amphibia form a major intermediate step in the development of higher terrestrial life from the strictly aquatic fishes. Amphibians have not made a complete break from their ancestral home, however, for most of them must spend at least part of their life in water. Reptiles are the first major vertebrate group to have members that are completely terrestrial. (Some amphibians are also completely terrestrial.) Reptiles are the most highly developed cold-blooded vertebrates and are the ancestors of the homeotherms, the birds and mammals.

The unique biological apparatus vital for existence on terra firma shows its initial development in the herpetofauna. This accounts in large measure for the interest in this relatively small group of animals by zoologists and biomedical specialists, e.g., embryologists. Because the vital functions and structure of reptiles and amphibians are so homologous to higher forms, they have been widely used in anatomy and physiology laboratories. Therefore, a veterinarian in private practice may occasionally be called as a consultant to advise care and treatment of a laboratory colony of frogs and turtles. These creatures are also commonly used in the household laboratories of budding scientists of high-school age.

There are three major living groups (subclasses or orders, depending on the exact classification scheme used) of the Class Amphibia. Gymnophiona contains the caecilians, which are limbless, burrowing creatures of the tropics. Since they are rarely kept as pets and little is known about their diseases, nothing more will be said about the Gymnophiona. We are primarily concerned with the salamanders (Caudata or Urodela) and frogs and toads (Salientia or Anura). The terms **urodeles** and **anurans** will be used in the following chapters in referring to these two groups.

There are four orders with living representatives in the Class Reptilia. One of these orders, Rhynchocephalia, is represented by a single species, the tuatara, a lizard-like reptile from New Zealand, which is now facing extinction. Little more will be said of this animal, for it is most unlikely to appear in an American veterinary hospital. Reptilian orders which will be considered are Chelonia (turtles and tortoises), often referred to as **chelonians**, Crocodilia (alligators, caimans, crocodiles, and gavials), referred to collectively as **crocodilians**, and Squamata, subdivided into two suborders: Lacertilia or Sauria (lizards) and Ophidia or Serpentes (snakes). For a detailed classification of the herpetofauna, consult standard zoology and herpetology texts.[10,75]

Table 1–1. Some Differential Features Between Reptiles and Amphibians

AMPHIBIA	REPTILIA
1. Most species have metamorphosis from egg to larva to adult.	1. No distinct metamorphosis; the young generally resemble the adult in form.
2. Skin moist and glandular (except most adult toads, few salamanders).	2. Skin dry and cornified, glands few, never generalized.
3. No external scales.	3. Skin usually has scales or scutes.
4. Skull with 2 occipital condyles.	4. Skull with 1 occipital condyle.
5. Heart 3-chambered (1 ventricle, 2 atria).	5. Heart imperfectly 4-chambered (ventricles imperfectly divided; division almost complete in crocodilians).
6. Gills present at some stage of metamorphosis; some respiratory exchange through skin and buccal mucosa in many species; lungs in most adult amphibia.	6. Respiration by lungs; cloacal respiration in aquatic turtles.
7. Ten pairs of cranial nerves.	7. Twelve pairs of cranial nerves.
8. No embryonic membranes.	8. Amnion, chorion, yolk sac, allantois.
9. Mesonephric kidney (adult amphibian; pronephric kidney in larval stage).	9. Metanephric kidney.

It may be helpful to compare reptiles and amphibians, pointing out some major differences between the two groups (Table 1–1).

Applied Anatomy and Physiology

Detailed discussion of organ structure and function is not within the scope of this work; texts that deal specifically with these subjects should be consulted.[3,10,22,23,48,54,73,75,78] Coulson and Hernandez have published a number of metabolic studies of the alligator, summarized by them in 1971.[23]

It may be helpful in considering the following data on normal structure and function to think in terms of evolutionary adaptation, with development occurring in a stepwise manner from larval to adult amphibian to reptile to a creature that could live on dry land. The move from aquatic to terrestrial habitation was a major evolutionary step and required many changes in all organ systems. Within this evolutionary framework the following discussion will emphasize selected areas of clinical importance.

Growth, Metamorphosis, and Longevity

Many reptiles and amphibians, particularly snakes, tend to increase in size throughout much of their life, although growth is slowed markedly at some point in maturation and usually stops before termination of the natural life span. It is possible that some species, e.g., crocodiles and pythons, may grow as long as they live, although at a much slower rate as they grow older. This is in contrast to mammals, in which growth ceases with closure of the epiphyses relatively early in the life of the individual, and the period of growth is more sharply defined than it is in herpetofauna. In reptiles, the epiphyses may never unite. Indeed, some reptiles lack epiphyses.[53]

*Table 1–2.** Longevity

NAME	YEARS	NAME	YEARS
AMPHIBIANS		Tiger salamander (*Ambystoma tigrinum)*	11
Congo eel *(Amphiuma means)*	27	Bullfrog *(Rana catesbeiana)*	16
Hellbender *(Cryptobranchus alleganiensis)*	29	Leopard frog *(R. pipiens)*	6
Mudpuppy *(Necturus maculosus)*	9	American toad *(Bufo americanus)*	10–15
American newt or eft *(Notophthalmus [Diemictylus, Triturus] viridescens)*	3	South African clawed toad *(Xenopus laevis)*	15
		Tree frog *(Hyla arborea)*	14
REPTILES		Fence lizard *(Sceloporis undulatus)*	4
American alligator *(Alligator mississippiensis)*	56	Anole *(Anolis* sp.)	3
Caiman *(Caiman niger)*	28	Galapagos tortoise *(Testudo elephantopus)*	100–150
Boa constrictor *(Constrictor constrictor)*	23	Box turtle *(Terrapene carolina)*	83–88
Cottonmouth moccasin *(Agkistrodon piscivorus)*	21	Snapping turtle *(Chelydra serpentina)*	20
Rattlesnakes *(Crotalus* sp.)	12–22	Painted turtle *(Chrysemys picta)*	11
Garter snake *(Thamnophis ordinata)*	11	Red-eared turtle *(Pseudemys scripta)*	7
Rat snakes *(Elaphe* sp.)	17–23		
Bull snake *(Pituophis catenifer)*	18		

*Derived from Tables 126 & 127 in Growth, Fed. Amer. Soc. Exper. Biol. 1963, 454–457.

The herpetofauna generally live longer than mammals of similar size. Longevity records, rounded in years, of various representative species are given in Table 1–2.

It is often claimed that the largest pythons, tortoises, and crocodilians live for two or three centuries. This might be true, but such reports are usually difficult to prove.[51]

Reptiles are born or hatched looking like miniature adults. They develop by growth and maturation of the various organ systems basically in the pattern seen in mammals. Many amphibians, on the other hand, go through **metamorphosis**. In frogs and toads there is, typically, a change from egg to free-living larva, or tadpole, to adult. In some tropical anuran species the tadpole is not free-living, but develops within the egg membrane, small adult forms eventually emerging from the egg. Most frog and toad eggs are deposited in water, but in some tropical species eggs are carried by the female, young adult forms eventually popping out of her skin (literally).

Development of a tadpole is divided into three phases. **Premetamorphosis** starts with emergence from the egg; towards the end of premetamorphosis the hind legs appear, but this period is mainly characterized by an increase in size with little morphologic change of the tadpole form. This is followed by **prometamorphosis** in which there is maturation of organ systems as well as continuation of growth. Prometamorphosis ends with the emergence of the forelegs and is followed by a **climactic phase** in which the tail and gills are resorbed, the mouth widens, and the adult form is assumed.

The metamorphic process is controlled by the hypothalamic-pituitary-thyroid axis and is dependent on increasing levels of thyroid hormone for normal development. According to the theory of metamorphosis-activation,[37] thyroid activity is relatively low in premetamorphosis. During prometamorphosis, thyroid hormones act by a positive feedback mechanism on the hypothalamus. Hypothalamic neurosecretory activity causes increased secretion of pituitary thyrotrophic hormone by decreasing the sensitivity of the pituitary to thyroid hormone. Thus, increasing levels of thyroid hormones increase neurosecretion of the hypothalamus, which causes increased output of thyrotrophic hormone by the pituitary gland which, in turn, further stimulates secretion by the thyroid. This positive feedback continues until a critical level of maturation when the hypothalamus loses its positive sensitivity to thyroid hormones. At this time (climax) the thyroid-pituitary axis behaves in a negative feedback manner, as in mammalian physiology.

Details of metamorphosis vary considerably among anuran species. Time of development from egg to adult varies from one month in the spadefoot toad *(Scaphiopus hammondii)* to two or three years in the bullfrog *(Rana catesbeiana)*.

Frieden has written an interesting and informative review on the biochemistry of amphibian metamorphosis.[44] A summary of some of the major developmental changes from tadpole to adult frog or toad is given in Table 1–3.

Table 1–3. Summary of Metamorphic Development of Frogs and Toads

BODY PART OR FUNCTION	TADPOLE	ADULT
Extremities	Tail; hind legs emerge in premetamorphosis, forelegs in prometamorphosis.	Tail resorbed; legs fully developed.
Diet	Algae, aquatic life. Food is predominantly vegetable matter.	Insects, worms.
Digestive tract	Mouth narrow, gut long.	Mouth widens; tongue elongates; stomach, liver and pancreas increase in size; intestine is shortened. Pancreatic and intestinal secretions increase.
Respiration	Gills. (Respiratory exchange may also occur across skin and mucous membranes.)	Lungs. (Respiratory exchange may also occur across skin and mucous membranes.)
Heart	One atrium, 1 ventricle.	Two atria, 1 ventricle.
Nitrogenous excretion	Chiefly ammonia. Pronephric kidney functional in young tadpoles; mesonephros becomes functional in older tadpoles.	Chiefly urea. Mesonephric kidney.
Hemoglobin	Stronger tendency to bind O_2; no Bohr effect.	Greater tendency to release O_2, which increases with decreased pH (Bohr effect).