III. REPTILES*

A. INTRODUCTION

1. Reptiles in Nature

Modern reptiles have been derived from semi-aquatic amphibian ancestors of the Carboniferous period. Ancestral reptiles subsequently separated into the two distinct evolutionary lines from which mammals on one hand and birds and most living reptile groups, on the other, were to originate (Romer, 1966; Kemp, 1982).

During the Mesozoic Era, at least 15 distinct orders of reptiles existed; today only four persist (Kemp, 1982). These four orders contain some 6,000 species, 5,400 of which belong to the order Squamata (lizards and snakes). Indeed, this order and the order Chelonia embrace the only reptilian groups that are worldwide in their distribution and can, generally speaking, be considered to be securely entrenched in today's world (Schmidt and Inger, 1957; Carroll, 1969).

Virtually all major groups of reptiles contain some endangered species. Notably, most species of tortoises and all marine turtles among the chelonians, nearly all species of crocodilians and a majority of the large constricting snakes (family Bordae) are endangered. The Sphenoden, the sole surviving member of the order Rhynchocephalia, is limited to a single island in Cook Strait, New Zealand (Schmidt and Inger, 1957).

The homeostatic abilities of reptiles are far less well-developed than birds and mammals. Reptiles are ectothermic and, under natural conditions, select microenvironments in which they can gain or lose heat as required to maintain their body temperatures. Their thick, keratinized skin better protects them from water loss and absorption of noxious substances from their environment than does the moist, permeable skin of amphibians.

Various considerations and procedures pertaining to field studies on reptiles indigenous to Canada are dealt with elsewhere in this volume (Chapter XXII, Wild Vertebrates in the Field and in the Laboratory) and in the several field guides for American reptiles and amphibians (Conant, 1975; Stibbons, 1966). Veterinary biology and medicine of these species are described in the literature (Marcus, 1981).

2. Reptiles in Captivity

The points outlined above, as well as the pertinent national and international conservation regulations and objectives relating to endangered species must all be given careful consideration when making decisions as to the use and maintenance of reptiles for study in captivity. Certainly, the apparent survival difficulties of many species of reptiles in nature emphasize the absolute obligation and necessity to accumulate as much information as possible on the biology, behavior and environmental needs of the species to be studied, prior to attempting its maintenance in captivity.

Under captive conditions, reptiles must be provided with temperatures, humidity and a light cycle that will allow normal physiological functioning and behavior of the species being maintained. Specific information on these requirements and the care of the particular species to be held in the facility must be obtained in advance by the investigator if successful maintenance and meaningful study is to be achieved.

The diversity of adaptations and environmental requirements of reptiles dictates that this chapter be restricted to stating general principles and indicating the broad environmental conditions required in the laboratory use of reptiles. Those species indigenous to and/or commonly studied in Canada have received particular emphasis.

B. HOUSING REPTILES

1. General Requirements

The number of reptiles present in an animal facility is frequently insufficient to warrant their being provided with a separate room for each species, or even groups of species with similar environmental requirements. Usually, most or all the reptiles in the facility will be housed in one room, often along with some amphibians or fish.

Holding animals with different environmental requirements in a common room is manageable provided that only general conditions are established for the room as a whole. The individual terraria and tanks within the room are then set up as environmental chambers with independent control of temperature, humidity, light intensity, etc., at levels suited to the occupant species.

Captive reptiles require an environmental temperature at or near their optimal body temperature, as they are ectothermic and essentially incapable of metabolic thermoregulation (Davies, 1981). Optimal temperatures for most reptiles are in excess of 25^{o}C and many, especially lizards, have optimal temperatures between 35^{o}C and 40^{o}C.

2. Aquatic Holding Systems

a. Freshwater Turtles

These are the only highly aquatic reptiles commonly held in laboratories in Canada.

Flow-through water systems, supplying regular fish tanks are suitable for turtles. Water levels can be lower than for fish, with the depth sufficient for turtles to completely submerge.

A platform just clear of the water surface should be provided as a resting board on which the turtles can haul out. A few species, such as the common snapping turtle, will usually not use a resting board. As turtles must be able to get a purchase with their claws in order to pull themselves out of the water, resting platforms are best made of wood. As wood resting platforms are more or less continuously water soaked, they are probably best left unsealed and replaced at intervals as required. Even epoxy or polyurethane wood finishes will deteriorate quickly under continuous soaking at warm temperatures. Water temperatures should be held at about 30^{o}C for most North American freshwater turtles. An incandescent lamp positioned over the resting platform will allow basking turtles to increase their body temperature further.

b. **Other Aquatic Reptiles**

Aquatic housing is a requirement for several other reptilian species including sea turtles, crocodilians, venomous sea snakes, and a few lizard species. These are encountered so rarely in laboratories that their individual requirements will not be discussed here in detail. It should be noted, however, that all require temperatures in the 30-35^{o}C range; marine turtles and sea snakes require sea water and crocodilians, depending on species, require either fresh or salt water. Crocodilians also require a relatively large area above water level where they can rest and bask. Enclosures should always be sufficiently large to allow free movement of the animal(s) (Orlans, 1977).

3. **Terrestrial Holding Systems**

a. **General**

Most lizards and snakes, as well as the more terrestrial types of turtles can be kept in terraria.

A terrarium may be specially constructed or simply be a modified aquarium or other secure type of enclosure of appropriate size (Orlans, 1977). Regardless of what type of terrestrial cage is chosen, it must be possible to control the environment conditions within it to meet the needs of the species to be housed. Its construction and design should always be such as to satisfactorily accommodate each of the following points b) to g).

b. **Security**

Snakes, in particular, can escape seemingly tight enclosures with astonishing ease, a capability shared also by most small lizards. Terraria should have tight seams, with all holes securely screened, and be provided with well-fitted lids or doors which can be securely fastened down. It is not sufficient to rely on the weight of the lid alone to hold it down. All doors and lids must be fitted with latches, hooks or hasps.

c. **Temperature and Light**

It should always be possible to control temperature independently of light. An incandescent light or sun lamp is a useful source of supplementary warmth for basking reptiles, but should never be the sole source of either heat or light. Room controls, a space heater or "heat tape," of the sort used to prevent water pipes from freezing, may be used to maintain suitable temperatures when the lights are off. A regular day/night light cycle should always be maintained unless experimental conditions dictate otherwise.

d. **Air Exchange and Humidity**

Reptiles, in general, are better able to prevent water loss from their bodies than are amphibians and can, therefore, withstand lower humidities. However, a low humidity can be hazardous for small individuals and those species adapted to humid, tropical conditions. Some means of control of air exchange within the terrarium, as well as the room as a whole, should be provided. Neither a completely open unit, such as a wire-mesh mammal cage, nor a tightly closed one is desirable. Ventilation ports must always be screen covered to prevent escape. Ports should also be easy to block, partially or completely as required, to assist in humidity regulation.

Species of snakes which normally live under humid tropical conditions, will require a relative humidity between 60% and saturation in their terraria. Failure to maintain a high humidity may result in inability to shed the skin completely (see following section on Health Care and Disease). Elevated humidity of 70%-90% can be maintained by evaporating water from a container placed near the heater or light, and/or by hanging an absorbent paper wick with one end in a dish of water. Ventilation ports should be covered with a porous paper cover to reduce air exchange.

e. **Servicing and Viewing**

Terrarium doors and lids should, with the exception of those housing venomous snakes (see 4c), be constructed so that the entire top or an entire end or side opens, to facilitate cleaning.

Wood is an acceptable material for terrarium construction, but it should be finished so that it is easy to clean and will withstand water washing; polyurethane or epoxy paint or varnish have both proven suitable for this purpose.

An opaque top and three opaque side walls are generally preferred for terraria. If top and sides are transparent, most reptiles must be provided with a covered area so that they can shield themselves from light and outside disturbances. One full side should always be of glass or plexiglass in order to allow easy viewing of the inside of the terrarium. In the case of highly irritable or easily frightened reptiles, the clear wall can be provided with a partially or completely removable covering.

f. **Water Supply**

Most snakes, terrestrial turtles, and lizards, other than some desert-adapted species, need, and will drink, standing water. Many snakes, in fact, will submerge themselves in water, especially just prior to shedding.

As a general rule, snakes should be provided with a water container large enough to allow them to coil up and submerge. Other terrestrial reptiles should be provided with a dish of water.

An appropriate water source for very small snakes and lizards, as well as for desert adapted forms, is a petri dish cover holding a water soaked sponge, or filled with a layer of absorbent cotton soaked with water. This will provide adequate water and reduce the hazard of these small reptiles becoming trapped and drowning in their water dishes.

g. **Substrates**

A variety of substrates may be used in reptile terraria. Many lizard species such as the horned lizards (*Phrynosoma*) and such snakes as the hognosed snakes (*Heterodon*), normally burrow in loose sand. These animals should be provided with this type of substrate in captivity.

Coarse, flat wood shavings, such as softwood planings, make a useful substrate for many species. Fine sawdust should be avoided as there is a risk with this, or any other small-particle substrate, that snakes, in particular, may ingest substrate particles with their food. This can cause serious mouth or internal injuries from wood slivers, and occasionally, a bowel obstruction when large amounts of substrate are ingested.

Absorbent paper (such as cage-pan lining paper) or a piece of synthetic fibre indoor/outdoor carpet can be used as a solid substrate. Where a solid substrate has to be used for burrowing reptiles, a shelter box which simulates the darkness of a burrow should be provided.

4. **Housing Venomous Snakes**

All the requirements and considerations previously discussed are equally applicable to venomous snakes. In addition, the following precautionary criteria should be met:

a. **Ventilation Ports**

All openings except the lid should be covered with a double layer of screening. These layers must be separated by a space wider than the length of the snake's fangs to provide effective protection. Two and a half cm of separation between inner and outer screens is a sufficient distance for all, but the largest vipers.

b. **Viewing Walls**

Removable opaque covers should be fitted to the outside of these, since many venomous snakes are highly irritable. Furthermore, the clear viewing wall should be constructed of plexiglass, rather than glass, to ensure against shattering and possible escape.

c. **Access**

Only the lid of a venomous snake terrarium should open and the terrarium should be deep enough to at least slow down any attempt by the snake to climb to the top. If floor level doors are used, it is absolutely necessary to be able to see the snake while opening the door and for the door to be hinged in such a way that, when being opened, it will provide a barrier between the inside of the terrarium and the body of the operator.

d. **Other Security Precautions**

A formalized security and inspection system should be implemented to ensure that access door and lids are kept locked and that the uninformed and the curious cannot gain access to the terraria.

Before venomous snakes are received, proper training of all personnel who will be exposed to them should be instituted.

The institutional or other appropriate medical authorities should be informed of the types of venomous snakes to be kept, so that the appropriate precautions (stock of antisera, etc.), may be provided for in advance of any possible emergency.

C. FOODS AND FEEDING

1. General Comments

The majority of reptiles are predators, some of which exhibit extremely narrow and specific diet specializations. As is the case with amphibians, there is, in many species of reptiles, a strong behavioral bias towards movement in the recognition of their prey, and an aversion to feeding on dead animals. The nutritional requirements of reptiles are not well understood, although a number of recent reviews have dealt with the health aspects of these topics (Jackson and Cooper, 1981; Wallach, 1978). At present, the poverty of reliable information on reptile nutritional requirements and feeding behavior is such that they probably rarely receive either properly balanced or adequately varied diets in captivity.

Most reptile species will require live foods that are either the same as, or closely resemble their natural foods. Food should be offered between once and three times weekly in most cases, and the animal should be fed to satiation at each feeding. One should refer to the section on feeding in Chapter II, Amphibians, and the section of nutritional health in this chapter, for further discussion of these matters.

Some reptiles (highly irritable rattlesnakes, for example) find captive conditions so disruptive that they often will either not feed at all, or will feed only under conditions of total isolation in which feeding cannot be observed.

Problems resulting from the excessive ingestion of particulate substrate by snakes can be countered, where the animal is feed on dead food, by providing a clean dish or other solid surface for the food. In species which must attack and kill prey, the location of the food cannot be regulated and prevention of the problem will require a change to a solid substrate.

Stress resulting from inability to adapt to the more or less unsuitable environments of captivity may lead to anorexia, which, if prolonged, results in progressive weakness, emaciation and eventual death from starvation. In such cases, force feeding should be used well before the animal becomes emaciated (Jackson, 1974). At the same time, attempts should be made to modify the animal's environment so that it will feed naturally.

An ethical problem is presented by the food requirements of captive snakes and some other reptiles that must be fed living, fully conscious small mammals or birds. The only alternative is force-feeding, which risks injury to the animal being fed and possible nutritional deficiencies. In the case of venomous snakes, it also places the handler at risk. In all such cases, the research or teaching value of maintaining the captives must be weighed against the exposure of conscious higher vertebrates to attack by a predator.

2. Turtles (Order Chelonia)

a. Carnivorous Species

Snapping turtles (*Chelydra*), softshells (*Trionyx*), and pond turtles (*Pseudemys* and other genera) feed in the water, consuming aquatic invertebrates, fish and frogs. Large snappers may occasionally take wading or swimming birds. In captivity, all will feed readily on dead food. Whole fish are preferable, but pieces of fish fillet are readily taken. Most individuals will also take pieces of liver and meat.

In captivity, turtles, especially juveniles, are prone to calcium deficiencies. These result in a number of metabolic osteopathies, the most common of which is a nutritional osteodystrophy manifest by shedding of epidermal scutes, softening of the shell and general lethargy, eventually ending in death (Jackson and Cooper, 1981). These calcium deficiency diseases are generally due to diets that provide an improper calcium to phosphorous ratio (Fowler, 1978). The role of Vitamin D in maintaining the balance in reptiles is unclear (Dacke, 1979). The effects of the deficiencies are difficult to correct once they become established and the best method is to avoid the problem by providing foods, such as whole animals, which contain ample proportional amounts of phosphorous and calcium in the form of bone. The diet of the turtle requires a calcium: phosphorous ratio of approximately 1:1. Many vegetables and fruits provide adequate Ca:P ratios; however, meats without bone are inadequate sources of calcium (Wallach, 1978).

b. Omnivorous and Herbivorous Species

Terrestrial turtles (*Terapene*, *Gopherus*, *Geochelone*, *Testudo*) and other "tortoise" or "box turtle" types are omnivorous or herbivorous and will all feed on a mixture of soft fruits and leafy green vegetables. Mealyworms (*Tenebrio* spp.), as well as other insect larvae and adults, may be successfully fed to *Terapene* and probably other land turtle species. However, their chitinous exoskeletons do not provide Ca and, in common with other insects, provide an inadequate Ca:P ratio.

3. Lizards (Suborder Lacertilia)

Most living reptiles are lizards and, although the group is not well represented in Canada, there are about 4,000 species throughout the world, mostly in warm, dry areas.

a. Carnivorous and Insectivorous Species

Most lizards are insectivores which, in nature, are often adapted to specific prey types. In captivity, small insectivorous lizards can often be induced to feed on earthworms or nymph and larval stages of insects. It should be noted that *Tenebrio* larvae do not seem to cause the problems in lizards that they do in amphibians when used as a major component of the diet. Some of the larger predatory types of lizards, including monitor lizards (*Varanus* and *Lanthanotus*), tegus (*Tupinambus*) and amievas (*Amieva*), can be induced to feed on pieces of meat without difficulty.

A few examples of lizards that exhibit restricted diet tolerances are:

i. Small arboreal gekkoes (*Hemidectylum*, *Gonatodes*, etc.), which will usually only accept flying insects. They have been successfully maintained for a few months on fruit flies (*Drosophila*) and on houseflies trapped in stables.
ii. The Western alligator lizard (*Gherronotus caeruleus*) of British Columbia, which seems to consume spiders more readily than other prey items.
iii. Some individual horned lizards (*Phrynosoma*) which, when held in captivity, will accept only ants as food.

These examples are cited to emphasize the fact that narrow diet preferences may be encountered among lizards. It must also be noted that different investigators may well have different experiences with members of the same group, including those mentioned here. Lizards are a very diverse suborder and their diets are so poorly understood that there is very little reliable baseline information available.

b. Herbivorous Lizards

Special mention must be made of some of the larger sized lizards of the family Iguanidae, which are herbivorous and will readily feed on pulpy fruits and leafy green vegetables. These genera of New World lizards include the Iguanas (*Iguana*), Ground Iguanas (*Cyclura*), Spiny Iguanas (*Ctenosaura*) and Chuckawallas (*Sauromalus*).

4. Snakes (Suborder Serpentes)

a. General Feeding Habits

Although not as diverse as lizards, snakes are a widespread group and comprise most of the remaining reptile species. All are predatory, with natural foods ranging from soil-dwelling invertebrates to medium-sized mammals. Snakes are incapable of breaking up food and so must swallow anything they eat whole. Although many snakes will not accept dead foods, some will and, fortunately, a number of these are found among the species commonly held as captives.

b. Garter Snakes

In Canada, garter snakes, chiefly *Thamnophis sirtalis*, are among the most common species held in captivity. Most *Thamnophis* species (*sirtalis*, *radix*, *elegans* and *proximus*) will feed readily on pieces of fish fillet. This is also true for water snakes (*Nerodia* spp.). Whole, frozen minnows (mostly *Notropis hudsonius* and *N. atherinoides*) have been successfully fed to these species. However, young snakes under a year old should not be maintained on frozen minnows for more than a month or they may develop signs of sickness, possibly attributable to a nutritional deficiency. Affected snakes arch their necks and hold the heads vertically, or even upside down over their backs. They develop uncoordinated, spastic body movements and lose their ability to right themselves. Death will occur within two to three days. Though the cause is unknown, it is postulated that it may be a thiaminase induced Vitamin B deficiency. Whether or not the feedings of other minnow species will have similar effects is not known, and further study on the use of small cyprinids as food for captive *Thamnophis* and *Nerodia* species seems to be indicated.

Certain common fish such as fresh water smelt (*Osmerus mordax*) and cod (*Gadus* sp.) contain high levels of thiaminase (Jackson and Cooper, 1981; Geraci, 1981). Thiamine deficiency (hypovitaminosis B) occurring in aquatic turtles and water snakes may be attributable to diets of thiaminase rich fish (Wallach, 1978).

c. Constrictors

Various species of large constrictors are, next to garter snakes, the most commonly encountered captive snakes being studied in Canadian institutions. Species maintained include the boa constrictor (*Constrictor constrictor*) ground boa (*Epicrates* sp.), anaconda (*Eunectes murinus*) and various species of pythons (*Python* sp.). All of these tropical snakes are predators on mammals or birds in nature. Most have sensory pits in their upper and/or lower labial scutes which detect infrared radiation, a mechanism of locating endothermic prey in the dark. Individuals will readily feed on live, small mammals and can usually be successfully conditioned to feed on dead, whole carcasses of small mammals.

Depending on the behavior of the individual captive constrictor, conditioning may involve no more than presenting a dead carcass as food instead of a live animal. Other individuals will need to be trained in stages, first to accept a warm, moving carcass, then a warm, but not moving and finally a non-moving carcass at room temperature.

d. **Pit Vipers (Family Crotalidae)**

Rattlesnakes (*Crotalus* and *Sistrurus*) as well as all other pit vipers, are small mammal predators. These can be among the most difficult of snakes to feed in captivity. Captives are often so irritable that they will respond adversely to any stimulus, including food, by assuming a defensive posture and/or rattling. Where it is necessary to keep such individuals, covering the viewing front of the terrarium with an opaque cover will usually alleviate some of the irritability. Food will, in some instances, be more readily taken when the room is dark than when it is lighted. Usually, vipers will accept only live small mammals as food, although some individuals will accept freshly killed carcasses if they are still warm. Of the rattlesnakes found in Canada, the Massasauga (*Sistrurus catenatus catenatus*) is among the least irritable of all rattlers and usually feeds readily in captivity. Prairie and Pacific rattler (*Crotalus viridis viridis* and *C. v. oreganus*) are moderately irritable, but will usually adapt to captivity without difficulty. Among the least adaptable to captivity is the Western Diamondback rattler (*C. atrox*) of the southwestern USA. This large, savage and formidable rattler will often severely batter itself by striking at movements in front of its terrarium unless an opaque cover is placed over the plexiglass front.

e. **Other Snakes**

A variety of colubrids comprise most of the remaining snakes likely to be held in captivity in Canada. Among the colubrids, Bullsnakes (*Pituophis*), Rat snakes (*Elaphe*), Racers (*Coluber*) and Kingsnakes (*Lampropeltis*), are all small mammal predators. Although individuals will vary in behavior, most will accept only live food. *Lampropeltis* also readily feeds on amphibians and reptiles, including smaller conspecifics, under captive conditions. They should not be housed with other snakes for this reason.

Three other diminutive colubrid genera that are found in Canada should also be mentioned:

i. Green snakes (*Opheodrys*) which are insectivores.
ii. Brown snakes (*Storeria*) which feed on slugs, earthworms and larval insects.
iii. Ringnecked snakes (*Diadophis*) which feed on amphibians, in particular the small plethodontid salamanders, as well as on other reptiles (newborn lizards or snakes).

A final group, the Hognose snakes (*Heterodon*), are primarily toad predators in nature. In captivity, most of these will feed on live frogs or toads, with a preference for the latter. Frogs are much easier to obtain than are toads and if, under captive conditions a Hognose snake will not accept them (frogs), they may be "scented" by rubbing with fresh toad skin immediately before feeding.

Hognose snakes have also been shown recently to take young rodents as food (Leevedy, 1982, Pers. Comm.), several having been maintained in captivity in excess of one year using live, unweaned, laboratory mice as the primary food source. A short period of conditioning was necessary, involving presenting the mice, briefly, under observation. After a while the captive Hognose would accept the mice as feed almost as soon as they were placed in the terrarium near the snake.

5. **Alligators (Order Crocodilia)**

In Canada, the only other reptiles likely to be found in laboratories are crocodilian species and these only very rarely. Caimans (*Caiman* sp.) and the American alligator (*Alligator mississipiensis*) will both readily feed on chunks of meat and fish, presented in a long pair of forceps, or on dead food, placed in the water in their tanks. Even when the food is seized out of the water, crocodilians will not eat it until submerged.

D. REPRODUCTION

1. Captive Breeding

Except on a limited and experimental basis, usually for studies in the field of reproductive biology, very few reptiles have been bred in captivity. The same reasons for this apply as were cited in the previous chapter on Amphibians.

In addition to research specifically oriented toward problems in reproductive biology, another situation under which captive breeding should be considered is for use in those projects which involve species that are endangered in the wild.

In general, any project requiring consumptive use of wild caught animals from a species or population which is rare or in danger of extinction or local extirpation should require rigorous justification, both in terms of predictable research returns and (probably more importantly) of potential benefit to the population under study, before it is approved by an institutional Animal Care Committee (ACC) and allowed to proceed. Captive breeding programs may be one way in which such projects could be conducted with minimal or no damage to the wild populations concerned**.

2. Reproductive Biology

a. Ovoviviparity

Reproductively, reptiles are higher vertebrates, either laying a leathery-shelled egg on land, usually in a protected site or nest that is selected and constructed by the female, or showing ovoviviparous development.

There is a broad correlation of ovoviviparity with more rigorous environmental conditions, so that as latitude and/or elevation increase, a higher proportion of the native species of reptiles will be ovoviviparous. This trend has even been shown to exist among populations of single species of reptiles (Fitch, 1970).

b. Sexual Maturity/Cyclic Activity

The factors which induce sexual maturity are not well understood for most reptiles. Garter snakes under simulated winter torpor conditions have spontaneously shown reproductive behavior and mating when re-warmed and activated. Females which have mated under these conditions have subsequently given birth to litters of young (Aleksiuk, Pers. Comm.).

While re-warming and activation may induce maturation in many temperate species which undergo winter torpor, the majority of reptilian species are either warm temperate or tropical. These species will not usually experience a sharply changing climatic cycle. Amongst at least some of these species sexual maturation seems to be governed by intrinsic rhythms which are retained even though cyclic variations in day length, rainfall and other environmental stimuli are completely absent or greatly disrupted in captivity.

Information on reproduction in about 800 species of lizards and snakes, some of which relates to maturation and reproduction in captivity, has been summarized (Fitch, 1970). A survey of reptilian reproductive adaptations and an excellent literature review up to 1972 is also available (Porter, 1972). Additional sources of information on captive maintenance and breeding of reptiles can be found in such publications as the International Zoo Year Book and the proceedings of the symposia of the Society for the Study of Amphibians and Reptiles. A recent issue of the latter contains a number of papers on aspects of the reproductive biology in a variety of reptilian species (Murphy and Collins, 1980).

c. Parthenogenesis

Several species of lizards of the genus *Cemidophorus* (family Teiidae) in North America and Lacerta (family Lacertidae) in Eurasia are apparently 3N, parthenogenetic, all-female species derived from hybridization between 2N bisexual parent species. No mating occurs in the derived species, and 3N females reared from hatching in isolation will deposit fertile eggs at maturity (Darevesky, 1966; Uzzell, 1970; Maslin, 1971). Another Teiid genus (*Gymnophthalmus*) may also include a 3N, all-female, parthenogenic species (Thomas, 1965), as may the Gekko genus *Hemidactylus* (Kluge and Eckardt, 1969).

E. HEALTH CARE AND DISEASES

1. Aquatic Species

a. Superficial Infections

Aquatic reptiles are particularly prone to superficial bacterial and, to a lesser extent, fungal infections. Bacterial infections can often be controlled by treatment with water-soluble tetracycline in the same way as for Red

Leg in frogs (see Chapter on Amphibians). Daily bathing with 1:100,000 potassium permanganate solutions for up to four days has proven useful in controlling superficial fungal infections. Similarly 3% NaCl dips may be useful in controlling *Saprolegnia* fungal infections which are common in turtles. Treatments of mycotic dermatosis with such agents as Nystatin, and Fungicidin (25,000 iu/100 g body wt.) or topically with Providone-iodine or Lugols solution have also been recommended (Holt, 1981; Burke, 1978).

b. **Systemic Infections**

Bacterial contamination hazards amongst aquatic reptiles can be induced or aggravated by dirty holding tanks and may result in systemic as well as local infection. Septicemic disease has long been a problem of both free living and captive reptiles. Bacteria that thrive in water (*Pseudomonas* spp., *Aeromonas* spp.) not surprisingly constitute the major threat to aquatic reptiles (Siegmund, 1979).

Signs of these generalized, systemic infections are variable and non-specific, although lethargy is common. In turtles, a reddish congestion of the plastron and respiratory difficulties are sometimes observed (Maslin, 1971). In many instances, animals may just be found dead with no prior signs of disease having been observed.

All chelonians, particularly the fresh water terrapins and turtles, can carry *Salmonella* infections without showing apparent signs of disease. Salmonellosis is a serious and not uncommon zoonotic disease in humans; consequently, it is important that all captive aquatic turtles be checked for the presence of this organism.

Treatment of these systemic bacterial infections in aquatic reptiles is generally unsatisfactory. Flow-through water supplies and frequent, careful cleaning of turtle holding tanks will help to prevent infection of uninfected turtles from water borne microorganisms. Newly acquired animals, from both wild and domestic sources, should be isolated for at least two weeks and any animals shown to be infected with *Salmonella*, *Pseudomonas* or *Aeromonas* should, except under exceptional circumstances, be destroyed as they pose a serious threat to the health of other reptiles and man.

2. **Terrestrial Species**

Superficial bacterial infections and infestations with ectoparasites are the most common health problems in terrestrial reptiles.

a. **Mite Infestations**

These usually arise from eggs surviving in the substrate in the terrarium and are frequently encountered in snakes and lizards. Heavily infested animals will appear to have dusty white areas associated with the head and around folds in the skin on the neck and legs. The white appearing areas result from densely packed mites.

Mites may be treated with an insecticide such as pyrethrin or rotenone dust. Treatment should always be accompanied by the thorough sanitization of the terrarium and replacement of the substrate, in order to eliminate the eggs. In most instances, the simplest and most effective treatment is the use of a small segment (about 1 x 2 cm) of dichlorvos ("Vapona" strip), taped to the inside wall of the terrarium or buried in the substrate for a period of up to four days. This should then be removed and replaced by dichlorvos hung in the infected reptile room for 21 days to stop re-infestation. There are no apparent toxic effects on the reptile from this limited exposure; however, the treatment should not be used where ventilation ports have to be partially or completely closed, nor on small reptiles of less than 30 cm long (Holt, 1981; Marcus, 1977). Furthermore, prolonged exposure to dichlorvos has been reported to cause death (Bush, Custer, Smeller *et al.* 1980).

b. **Mouth Rot (necrotic stomatitis)**

This is a bacterial infection of the oral mucosa seen in snakes, usually as a result of injury to the mouth during feeding or from accidental ingestion of substrate. Initially, affected animals will show reddened, irritated areas on the inner surfaces of the lips and gums, followed by ulceration and the appearance of a crusted serous exudate (necrotic plaques) in the affected areas. Severely affected animals will cease feeding and usually die. Treatment consists of thorough removal of the deposits with cleaning and disinfection of the lesion under anesthesia, followed by the application of a topical antibiotic preparation. The careful use of streptomycin has been recommended for this condition (Holt, 1981). However, whenever possible the antibiotic chosen as the therapeutic agent in this, as in all such situations, should be based on bacterial sensitivity test results. In mild cases, an oral antiseptic may suffice for treatment following debridement of the lesion. It is advisable to remove affected animals to a terrarium with a non-particulate substrate such as absorbent paper or indoor/outdoor synthetic carpet.

c. **Zoonoses**

In addition to the zoonotic risk from exposure to Salmonella infections from terrestrial as well as from aquatic reptiles (see under Systemic Infections), two points should be raised specifically with respect to garter snakes (*Thamnophis* spp.) in Canada:

i. Western equine encephalitis virus (WEEV) has been identified in the red sided garter snake (*T. sirtalis parietalis*) in Saskatchewan; however, its occurrence is extremely rare (Burton, McLintock and Rempel, 1966). Garter snakes have not been shown to play a role in the transmission of the virus to warm-blooded animals; however, this potential as a host to WEEV, which may affect humans, should be realized by investigators holding captive garter snakes.

ii. *Alaria* sp., a digenetic trematode parasite, which normally cycles through snails, leopard frogs and carnivores, commonly occurs as a second infective intermediate stage in garter snakes (Freeman and Fallis, 1973). Snakes are probably infected by eating frogs. On rare occasions, the metacercariae may infect humans by penetrating a mucosal surface. Two cases of transmission to humans have been reported, one from preparing infected bullfrogs for eating, the other a fatal infection from an unknown source (Freeman, Stuart, Cullen *et al.* 1976; Fernandes, Cooper, Cullen *et al.* 1976). Persons dissecting freshly killed garter snakes or frogs should be aware of this hazard and should wear disposable gloves and be careful to thoroughly wash their hands and disinfect the instruments used.

d. **Nutritional Health Problems**

General dietary deficiencies of aquatic reptiles and calcium deficiency disease in young Chelonians have already been described under Foods and Feeding. Abnormal calcification may also occur as a dietary problem in snakes, large lizards and crocodilians, again, usually in association with low calcium, high phosphorous, vitamin deficient diets (Davis, 1981; Wallach, 1978).

Vitamin A deficiencies occur with some frequency, particularly amongst captive terrapins, and may give rise to a "soft shell" comparable to that seen in osteodystrophy (Frye, 1973; Keymer, 1978).

e. **Skin Shedding**

Difficult shedding, a not uncommon health problem in captive snakes, is apparently associated with insufficient humidity in the terrarium and, perhaps also, with suboptimal temperatures. The hazard may be reduced by maintaining snakes at temperatures of 30-35^{o}C and relative humidities at 75% or greater. Where room humidity control is not available, 75 to 90% humidity can usually be achieved within individual terraria by closing ventilation ports with porous barriers and increasing the rate of water evaporation by hanging a filter paper strip from the water dish as a wick from which water will evaporate. Suspending a shallow water pan close to the light will also accelerate evaporation.

In animals which have failed to shed or have shed incompletely, the unshed skin must be removed manually by:

i. confining the snake in a vessel large enough in which it can coil;
ii. filling the vessel with a 30^{o}C solution of 2% liquid detergent and 2% glycerin just deep enough to cover the thickest part of the snake's body; and
iii. soaking the animal for an hour or more if necessary, and then rubbing with the fingers or picking with blunt forceps, to remove skin.

If shedding has failed around the head, the eyes should be examined carefully, under magnification if necessary, and unshed spectacles (the transparent scales covering the eyes) removed. Also, facial or labial heat-sensory pits in vipers and boids, respectively, require similar close attention.

Venomous or highly irritable snakes should be immobilized prior to such manipulations as assistance in skin shedding, to minimize danger to the handler and possibly injury to the snake. As these are not painful procedures, immobilization may be achieved by gradually cooling the snake, rather than using a chemical anesthetic. North American vipers and colubrids should be gradually cooled to $4^{o}C$ over a period of about four hours usually while in the soak bath. Tropical snakes should be cooled to $10-12^{o}C$, over about four hours. When these procedures are undertaken on venomous snakes, there should always be one person whose sole responsibility it is to control the head of the snake while it is being manipulated.

F. ANESTHESIA AND IMMOBILIZATION

Reptilian skin is relatively impermeable; therefore, chemical anesthetics must either be inhaled or injected even in those species that are more or less aquatic.

a. Inhalation

The use of inhaled 3% halothane/oxygen has been recommended for anesthesia (Bush, Custer, Smeller et al. 1980). Cyclohexane has also been used with success in this way. A serious difficulty with the use of inhaled anesthetics relates to the ability of most reptiles to hold their breath for minutes at a time. The reader is referred to the section and tables on anesthesia of reptiles in Volume 1 of this series for more detail.

b. Hypothermia

Unless pain producing procedures such as major surgery are to be employed, it often is more practical, less dangerous and probably less traumatic to immobilize reptiles by chilling, rather than with chemical anesthetics. Chilling should be done gradually, down to a temperature where normal movements, such as body flexion or tongue protrusion are very slow and weak. Chilling should be used only where restraint, not unconsciousness, is required, and should proceed only until the required degree of immobility is achieved. The animal can be rewarmed simply by restoring it to room temperature. Aquatic reptiles should be allowed to rewarm gradually in air and not by placing immediately in warm water.

G. EUTHANASIA

Even though a reptile may be killed quickly, its body movements will invariably continue through several minutes, while muscle movements may persist for hours.

a. **Anesthetic Agents**

Inhalation of volatile anesthetic gases are used, although, as previously noted, their usefulness may be complicated by the difficulties associated with slow respiration and breath holding. Ether should not be used as it has an irritant (excitation) effect and induces violent thrashing prior to the loss of consciousness. Halothane does not produce this violent response.

Overdoses of injectable anesthetic agents (barbiturate derivatives, MS-222, etc.), may be used without inducing any perceptible irritation or stress; however, they act only slowly unless injected directly into the bloodstream. Intravenous injection and cardiac puncture are technically difficult procedures that may prove very stressful to the recipient if not carried out expertly and are, therefore, not usually advocated for the induction of euthanasia.

b. **Physical Procedures**

A skull-crashing blow on the head, decapitation, or cervical dislocation will all produce instant death and may well be the most humane method to use whenever the experimental requirements and considerations of human sensitivities will permit.

Chilling to the point of torpor (usually 1-4^{o}C) prior to the application of other procedures for euthanasia may sometimes be useful. This involves:

i. placing the animal in a cloth bag which can be securely closed;
ii. putting the bag with the animal into a second container, which is then placed in a refrigerator or controlled temperature room until the animal becomes torpid;
iii. proceeding with euthanasia.

It is known that physiological functions such as oxygen consumption, digestion and muscle contraction are temperature dependent in reptiles. While Central Nervous System (CNS) electrical activity as a function of body temperature remains unnecessary, it seems reasonable to assume that it, too, is suppressed during cold torpor. On the basis of the above assumption, an animal that is in a state of cold torpor may then be killed by further lowering the temperature to induce death by freezing, without subjecting it to any pain whatsoever. Indeed, freezing euthanasia produces a relaxed specimen with no grossly visible structural damage, which is suitable for preservation as a museum specimen. However, cell damage due to ice crystal formation limits its usefulness for microscopic studies. As with decapitation and other physical methods of euthanasia, frozen specimens have not been contaminated by chemical anesthetics and may, therefore, be particularly useful in biochemical studies.

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