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CLINICAL ASPECTS OF REPTILE BEHAVIOR

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Over the past few decades great strides have been made to understand reptile pathology, disease, medicine, and surgery. Despite interest and publications on reptile behavior, however, there seems to be a distinct lack of information on reptile behavior etiology and specifically its relationship to health and disease.

Biologists, zoologists, and veterinarians appreciate the importance of understanding exotic animals, not merely as an indicator of disease, but also to assess welfare and behavioral enrichment. Recently, avian clinicians and behaviorists have undertaken assessment and behavioral modification of companion birds. There are great advances to be made in their comprehension of reptile disease and behavior, yet this area of herpetological medicine largely remains neglected.

The aim of this article is to provide some basis for the behavioral understanding of reptiles that may assist the clinician either when dealing with behavioral problems or when aberrant behavior may be an important clinical sign (Figs. 1, 2). With the vast number of reptile species represented in captivity, it is impossible to cover this subject in detail. Therefore, a few common presentations have been selected for discussion. Readers are advised to consult other works on the general principles of animal and the extensive information base on normal reptile behaviors.[8, 12, 15]

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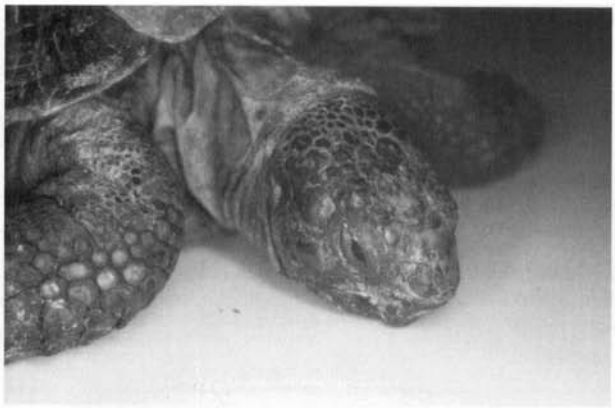

Figure 1. The extended head and limbs, half-closed eyes, and depressed demeanor of this tortoise are important behavioral anomalies that should be noted during the physical examination. Ivermectin toxicity was responsible in this case and the owner presented the animal because of the obvious behavioral changes. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

STRESS, PAIN, AND BEHAVIOR

Stress is a frequently abused term when attempting to evaluate or describe maladaption syndromes. Stress can be considered as the sum of the biologic reactions to any adverse stimulus (i.e., physical, mental, or emotional, internal or external) that tends to disturb the homeostasis

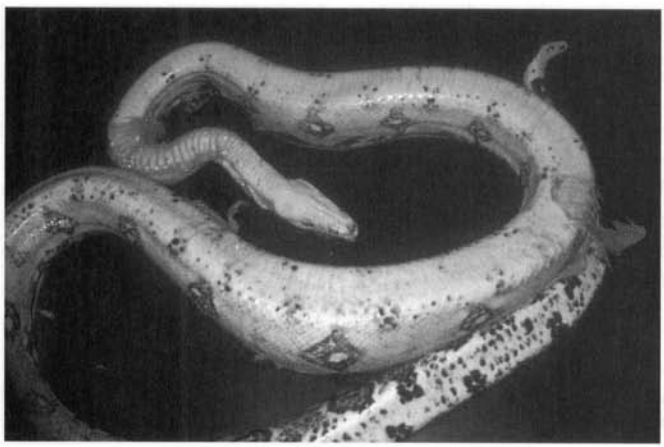

Figure 2. Dramatic behavioral changes are possible. This Boa Constrictor is suffering from a complete loss of righting and propioception reflexes. The behavioral and neurologic problems were subsequently attributed to boid inclusion body disease virus. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

of an organism. Should these reactions be inappropriate or prolonged, they may lead to disease. Those stimuli that can cause stress are termed stressors, and they may be physical (e.g., temperature), nutritional (e.g., starvation), or social (e.g., suppression by dominant individual).

In reptiles, the continuum of stressors can be artificially divided into two categories. Physiologic and psychologic. Physiologic stressors can be acute (e.g., limb fracture) or chronic (e.g., malnutrition). Psychologic stressors can be social dominance (e.g., multiple males), perception of predation (e.g., domestic cats), or emotional (requiring some form of higher intellect that may be inappropriate when discussing reptile stress and behavior).

Reptiles will attempt to cope with stress using both internal physiologic means (e.g., adrenocortical and autonomic nervous systems) and behavioral means. For example, a reptile provided with an inadequate thermal environment will be subjected to physical stress. To overcome, the animal will use normal basking behavior in an attempt to increase body temperature. If presented with an inappropriate heat source (such as 'hot rock'), however, this normal behavior may result in thermal burns. If behavioral means were inadequate, then over time this chronic stress would lead to immunosuppression, poor digestion, and secondary disease. Another common example is the anorectic Ball python (*Python regius*); this species is timid and secretive by nature, preferring to remain hidden rather than bask in the open. Keeping this snake in a glass enclosure without access to secure retreats can amount to unavoidable stress and subsequent anorexia. Additionally, in the wild, many of these snakes will become seasonally anorectic during the cooler months. Therefore, poor feeding behavior encountered in captive members of this species may be seasonally normal or a manifestation of environmental stress.

The ability to differentiate between normal and abnormal behaviors is an important aspect of captive reptile care and medical assessment (Fig. 3). Clinicians must be able to advise reptile keepers of their responsibility to recognize and facilitate the display of normal behavioral repertoires.

COLOR AND BEHAVIOR

Coloration plays a vital role in many aspects of behavior including: social interaction including courtship and reproduction; predatory and antipredatory; and thermoregulation.

It is clear that preferred coloration is likely to vary especially between vivid courtship displays and predatory-antipredatory concealment. Evolutionary pressures have directed and modified color adaptation; for example, vivid display colors are located ventrally or ventrolaterally and concealed unless specific postures are undertaken (e.g., dewlap extension) to display them. In general, the male with lower parental investment often is more colorful than the female.

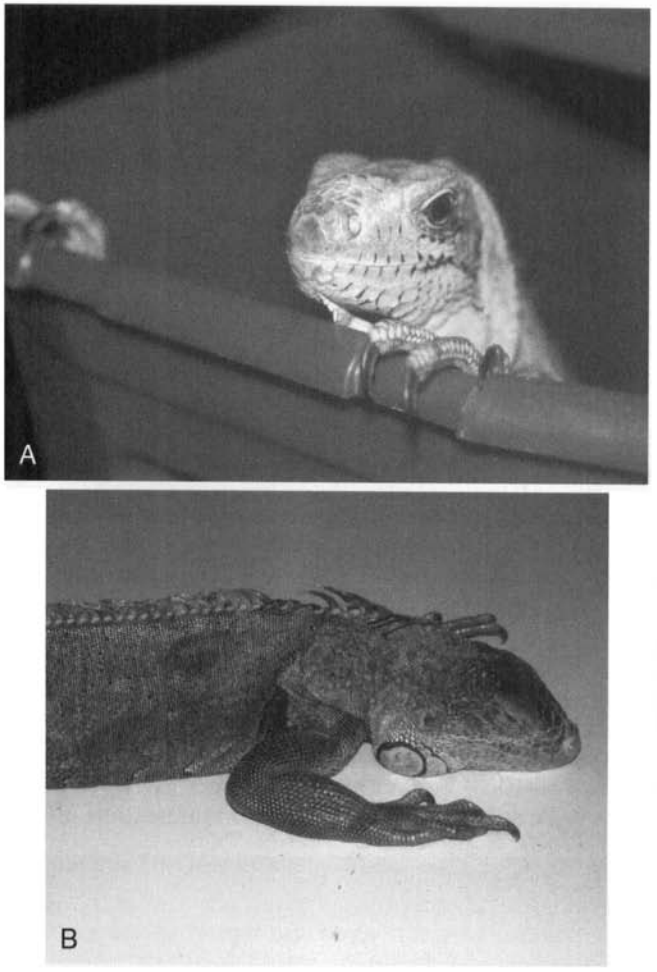

Figure 3. *A*, Reptiles like this Green Iguana should be alert and aware of their surroundings. *B*, By contrast, this female Green Iguana is collapsed and moribund, indicating the requirement for emergency stabilization. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

Some species, such as the coral snakes (*Micrurus* spp), have evolved bright coloration to warn of their venomous nature. Harmless kingsnakes (*Lampropeltis* spp) have chosen to mimic this coloration to dissuade predation. Coloration also is intricately involved with food acquisition, and many reptiles will use coloration and patterning to improve their camouflage as an adjunct to predatory and antipredatory behavior (Fig. 4).

Body coloration and behavior also is critical to thermoregulation,

Figure 4. Coloration plays a large part in many threat displays. In this example, the chameleon perceives an equally colorful veterinarian as a menace and is responding with an open-mouth threat and inflation of his body. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

because reflectance strongly affects the warming rates of animals exposed to solar radiation.[14]

THERMOREGULATION

Ever since Cowles and Bogart[5] demonstrated that reptile body temperature does not passively mirror that of the environment, the importance of both physiologic and behavioral means of thermoregulation have been realized. Much research has been undertaken on reptile thermoregulation, particularly in lizards.[1] Reptiles attempt to maintain a preferred body temperature using a combination of postural changes and movements between microclimates of differing temperatures. There are two main classifications of behavioral thermoregulation: basking in the sun (heliothermy) and absorbing heat by conduction from objects in the environment (thigmothermy). The understanding of these concepts by veterinarians and keepers is instrumental in producing the proper captive habitat for reptiles. The ability to display normal thermoregulatory behavior requires an environmental heat source and cage furnishings.

For diurnal species, an overhead, radiant heat source is more akin to the natural sun, whereas nocturnal reptiles perhaps are better cared for using low wattage background heaters such as under floor heat mats. Rocks and slates will absorb energy by radiation or conduction and then release this heat, usually by conduction, to reptiles in physical contact. Likewise, these furnishings allow the reptile to change the location and elevation of its basking site, thereby selecting a suitable

microclimate. Substrates and retreats are also important for reptiles to evade heat, especially from radiant sources.

The natural behavior of caged reptiles must be considered when selecting thermal provision. For example, the use of under floor heating would be completely inappropriate for burrowing species like the Calabar ground python (*Calabaria reinwardtii*) that burrow in the leaf litter to evade excess heat.

FORAGING AND FEEDING BEHAVIOR

In the wild, all reptiles have to search for food. In captivity, this is seldom the case, and ready food access predisposes to obesity. Reptiles can be broadly divided into herbivores, omnivores, and carnivores (including vertebrate and invertebrate items). There are, however, many dietary specialists including the ophiophagic (cannibalistic) snakes (e.g., Kingsnake, *Lampropeltis getulus*, and King cobra, *Ophiophagus Hannah*) and molluscivorous (snail-eating) lizards (e.g., the Pink-tongued skink, *Tiliqua gerrardii*).

Predation and Foraging

Visual, chemosensory, and infrared detection seem to be important senses, employed to varying degrees by different reptiles, for the purpose of food acquisition. Reptile feeding behavior can be classified into two types. "Sit and wait" predators remain in one place and wait for prey to pass within striking range. Some species have even developed lures to attract prey (e.g., tongue-lure of alligator snapping turtle, *Macroclemys temminckii*). "Widely foraging" reptiles roam over distances searching for food. This is particularly true of the herbivorous grazers, including most tortoises.

Whichever means for obtaining food is used, it is essential to be able to accurately identify food (be it plant or animal) through visual reception (eyes), infrared reception (sensory pits), mechanoreceptors (ears and integument), and chemoreception (tongue, nose, and vomeronasal organs).

Anorexia and Over-Feeding

When confronted by apparent anorexia in a captive reptile it is vital that an assessment be made as to the nature and means of food provision. Incorrect diet, inappropriate manner of provision (e.g., feeding nocturnal feeders during the day), and any trauma or disease affecting the senses can result in complete anorexia in an otherwise healthy animal. In addition to a review of the husbandry, a complete physical

examination including a neurologic evaluation is essential when dealing with any anorectic reptile.[2]

The opposite problem, overfeeding and obesity, is a result of both excess provision by the keeper as well as excess intake by the reptile. "Sit and wait" predators, such as many boas and pythons, will instinctively feed when prey pass within striking distance. Any rodent placed within the confines of a vivarium usually will fall within this strike distance and elicit a feeding response, even if the snake is well nourished. Regular provision of rodent prey to such snakes, without due regard to their nutritional needs, can result in obesity, especially in nonbreeding animals. A similar problem can exist when keeping tortoises (e.g., *Testudo* spp, *Geochelone* spp) in which individuals offered succulent foods without having to expend energy foraging can result in excess calorie intake. Overfed juveniles often develop shell deformities while adults may become obese.

DISTANCE-REDUCING BEHAVIOR

Distance-reducing behaviors are in many ways opposite to territorial behaviors (i.e., they function to bring conspecifics together and can be classed as social behaviors).[10]

Aggregation

The grouping of animals by common attraction has been reported in many reptiles and provides an obvious means of locating a mate. Such aggregations can occur for other reasons, however, including hibernation (e.g., rattlesnakes and garter snakes), feeding (e.g., water snakes), thermoregulation (e.g., iguanas), egg laying (e.g., sea turtles, lizards, and tuatara), and birth (e.g., prairie rattlesnakes, *Crotalus viridis*). In some cases, the precise control and reasons for such activities remain obscure. Although the precise control and modulation of such aggregations is still open to debate, in snakes at least, pheromones are known to play a key role (Fig. 5). Even though the appreciation of such communal situations may be limited, naturally gregarious species should have the opportunity to interact with conspecifics, since living in isolation may be detrimental to a social reptile's well-being.[9] For example, many lizard species, including the Leopard gecko (*Eublepharis macularius*) and Bearded dragon (*Pogona vitticeps*), appear to adapt well to captivity when maintained in single male, multiple female harems.

Courtship, Mating, and Reproduction

Although studies on sexual selection and mating systems in reptiles are largely lacking, the usually obvious courtship behaviors observed in

Figure 5. European Adders will often congregate in sizeable groups for communal courtship and copulation.

reptiles aids species recognition, gender recognition, mate evaluation, and reproductive stimulation.

The courtship behaviors of lizards have been well studied and documented to include head-jerking or head-bobbing, push-ups, dewlap extension, broadside posturing, tongue-flicking, and biting.[3] Male lizards can be quite aggressive, pursuing and biting the female across the dorsum and neck in an attempt to restrain her and align their cloacae for copulation (Fig. 6). Such encounters can result in severe lacerations to the nape of the female, who has little chance of escape when confined in a vivarium or other enclosure.

Courtship in snakes seems to be less visual but more tactile and chemosensory in nature. Snake courtship can be artificially divided into three phases: tactile and chase, tactile and cloacal alignment, and intromission and coitus. Male boids often use their vestigial pelvic spurs in tactile stimulation, while biting is restricted to the non-natricine colubrid snakes including some kingsnakes (*Lampropeltis* spp) and corn snakes (*Elaphe* spp).

Chelonian courtship appears to vary from visual to tactile. The male Red-eared slider (*Trachemys scripta elegans*) will "fan" the female by quivering his long forelimb claws in front of her in the water. By contrast, many tortoises are more physical with the male biting and shell-butting the female. Overzealous male tortoises can cause severe shell and limb trauma to females that have no means of escape, and as such, gender separation often is necessary in small captive environments.

Gravid females will often show increased basking and reduced feeding or foraging behaviors. Many females will become anorectic

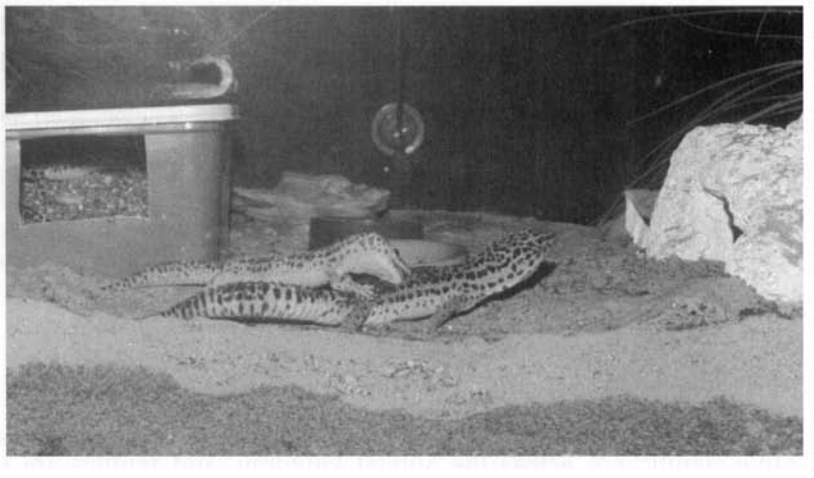

Figure 6. Many male reptiles will pursue and bite females during courtship and copulation. If the female is kept confined and has little opportunity to evade the continuous advances of an amorous male, severe trauma can result. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

during late pregnancy/gravidity; this lack of interest in food will commonly persist until egg laying or birth, often resulting in an obvious deterioration in body condition. The gravid female of some species will become more overtly aggressive to both conspecifics and human keepers. For example, the usually docile Burmese python (*Python molurus*) will often become unapproachable once heavily gravid or incubating her eggs. Some lizards, notably the *Chameleo* species, will darken in color indicating their gravid status to both male chameleons and experienced keepers alike.

At term, viviparous females will seek seclusion and give birth with few problems. Oviparous females, however, will seek out a suitable area for nest excavation, egg laying, and incubation. In the pursuit of a suitable egg laying area, some females may seem almost hyperactive in their drive to locate a suitable site. In normal circumstances, the female will often excavate a shallow nest and lay the eggs before covering them. If such a locality is not available, however, then one of two situations can occur: excavation and egg laying may be suppressed resulting in egg retention and dystocia; or, excavation may be redirected to solid floor substrates, resulting in limb excoriation, incorrect egg laying, and egg death.

Parental Care

Following egg laying some species (e.g., Burmese python, *Python molurus*) may actually incubate their eggs whereas others (including all

crocodilians so far studied) will protect their nest. Of the saurians, the Prehensile-tail skink (*Corucia zebrata*) generally gives birth to a single young and shows a degree of maternal protection for a short period of time after birth. Nevertheless, most reptiles (especially the chelonia) lack any obvious maternal behaviors.

There have been a number of reports of cannibalism of both eggs and young by conspecific adults. Some of these incidences seem to be triggered by a "feeding frenzy," but many remain unexplained, although the consequences of lack of seclusion and constant keeper disturbance should be considered.

ANTAGONISTIC BEHAVIOR

The concept of antagonistic, aggressive, or agnostic behavior has adaptive significance across the animal kingdom, and reptiles are no different. Antagonistic behaviors may be subtle (e.g., coloration, threat displays) or violent (e.g., aggressive attack) and invariably seek to impart dominance of one being over another or at least prevent a successful attack by a predator. Antagonistic behaviors are often an integral part of many ethologic repertoires, particularly territoriality, combat, and antipredation.

Territoriality

The maintenance of an exclusive area by aggressive means results in the phenomenon of territoriality. Many species of reptiles will display such intraspecific behavior, and although most often displayed by males, females of solitary species may also be pugnacious. Overt aggression is generally preceded by threat displays, particularly head bobbing, dewlap extension, body inflation, and open mouth displays. Some territorial species will be tolerant of other species (e.g., the human handler); for example, male Leopard geckos (*Eublepharis macularius*) will kill a fellow male gecko but are generally docile when handled. Conversely, a mature male iguana (*Iguana iguana*) will often be generally aggressive to any animal (including other iguanas, domestic pets, and people), particularly during the breeding season (Fig. 7). There has been considerable debate regarding whether these antagonistic behaviors are truly territorial or reproductive in origin. There have certainly been reports of male iguanas pursuing and attacking female owners in a courtship-like fashion.[7] In some cases, the surgical castration of these males can bring about a reduction in these aggressive courtship behaviors. The benefits, however, of castrating nonspecifically aggressive iguanas often appear less obvious, but not always completely ineffective at improving docility.[13] It seems that the earlier the surgery is carried out, the better the response at reducing overt aggression, with a significant reduction in response in animals over 2 years of age.

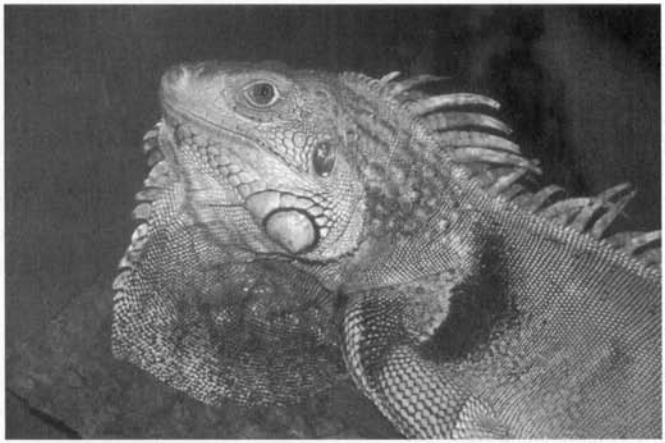

Figure 7. Adult male Green Iguanas are common pets but are known for their antagonistic tendencies. Castration may help, but careful behavioral and medical assessment is essential if clients are to be properly advised on the likely success, or otherwise, of the neutering procedure. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

Although overt aggressive behaviors are perceptible to humans, much more subtle behaviors may be obvious to reptiles but completely undetectable to the keeper and the clinician. For example, the prominence of a reptile's basking position may well bestow hierarchical dominance. Where such a dominant animal exists, subordinate animals may refuse to bask and feed properly resulting in anorexia and decline, often without any evidence of overt aggression or fighting. Subtle and yet pronounced territoriality can be most readily appreciated when studying chameleons (*Chameleo* spp). Many inexperienced keepers have learned that trying to maintain a group of chameleons often fails; individuals will refuse food and decline to the point of death. Separation of such animals out of visual range of more dominant individuals, however, often results in improvement. It is vital that clinicians appreciate, even if they cannot understand, the human-imperceptible behavioral repertoires that are critically important when housing more than one reptile in a vivarium. Indeed, the separation of a failing individual from a communal environment is one of the first steps that should be undertaken when dealing with any sick reptile.

There also is convincing evidence to suggest that many reptiles possess the ability to recognize their environment and the orientation of their enclosures.[4] For example, simply changing the location of cage furnishings has been shown to induce a significant increase in exploratory behavior and tongue flicking in snakes. It would seem that although a completely alien environment may be expected to act as a stressor, the partial alteration of the enclosure (e.g., after cleaning) may well increase exploratory behavior and act as a means for behavioral enrichment for snakes and probably many other captive reptiles.

Combat Behavior

The intricate courtship behaviors observed in mammals and birds are perhaps not as well developed in reptiles; however, there are some exceptions including ritual combat in certain snakes (e.g., Diamondback rattlesnakes, *Crotalus atrox*). During periods of combat and courtship behavior, many reptiles will be voluntarily anorectic. Normal breeding behaviors are an important differential in cases of presented anorexia. Concurrent hyperactivity is common in courtship–related anorexia, and this fact may be useful diagnostically.

Antipredator Behavior

Reptiles have developed a range of antipredatory behaviors.[11] These may be divided into three groups. Avoid detection by predator by immobility and cryptic coloration. Escape predator following detection by direct evasion or retreating to inaccessible sites. Repel predator following detection by biting or striking, emission of noxious chemicals (musk, feces, and urine), startle displays (mouth-gaping, cobra hooding), and death-feigning.

Although captive reptiles are unlikely to be exposed to true predators, a keeper may illicit similar responses through inappropriate approach or rough handling.

ESCAPE AND AVOIDANCE

A common concern when dealing with captive, nondomestic animals is stereotypic behavior and repeated attempts to escape or avoid stressful encounters with either the environment, conspecifics, or keepers.

Reptiles may attempt to repeatedly escape for a variety of reasons including: unsuitable environment (e.g., temperature, humidity, substrate, lighting, furnishings), inappropriate feeding (e.g., incorrect diet, inadequate food, prey attacking reptile), and intraspecific and intergender incompatibility (e.g. territorial males, overcrowding).

Alternatively, repeated interaction with glass can also lead to trauma, as many reptiles do not acknowledge transparent barriers. For example, Water dragons (*Physignathuus concincinus*) are often presented with severe rostral trauma caused by collision with vivarium glass; likewise many tortoises will abrade forelimbs as they attempt to breach wire fences (Fig. 8). It is clear that simply treating the traumatic lesions associated with escape is merely symptomatic. By appreciating the causes of such problems, clinicians can advise on improvements in husbandry and nutrition. For example, dark tape or painted lines across glass barriers will help depict a solid barrier, whereas the use of one-way glass may be even more effective. Garden enclosures should have

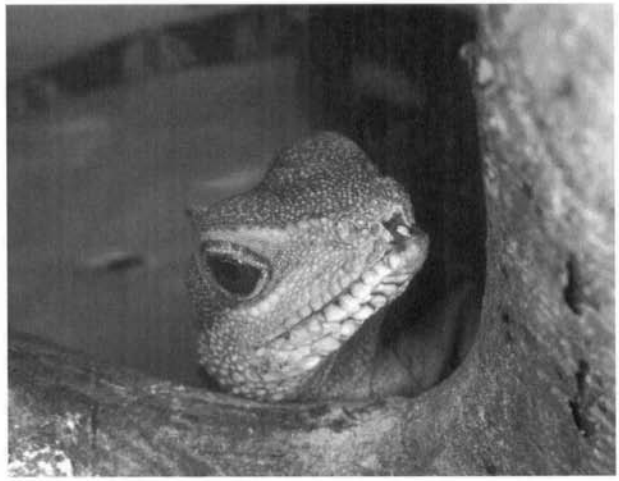

Figure 8. Water Dragons are known for rostral abrasions caused by their flighty nature and poor perception of invisible glass barriers. Treating the wound is merely symptomatic. Changes in husbandry and vivarium design are essential to prevent the problem. (Courtesy of Stephen J. Hernandez–Divers, DZooMed, MRCVS, Athens, GA.)

solid walls or fences as visual barriers. Preventing the visualization of what lies outside the enclosure often subdues escape attempts.

If escape or avoidance is unavailable then aggression or submission may ensue. Green iguanas (*Iguana iguana*) accustomed to captivity are well known for closing one or both eyes when approached or handled. Whether this behavior is truly indicative of contentment as suggested by many is open to debate. Until more is known, such avoidance may be related to fear, submission, or tolerance.[6]

SUMMARY

At first glance, the abstract world of reptile ethology may seem remote to clinicians dealing with the health and disease of captive animals. By delving a little deeper, however, veterinarians can learn to appreciate the reasons for certain behaviors and actually use these behaviors as indicators of various biologic states. Close scrutiny of subtle changes in behavior can further help assess reptile well-being and judge captive welfare. In the future, it is hoped that improved ethologic understanding will result in behavioral enrichment for reptiles, as is already promoted for many nondomestic mammals and birds.

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