

Basking Behavior of Painted Turtles

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Some vertebrates are biologically familiar to all biology teachers. Others, however, are not given more than a passing glance by teachers or students. Turtles are a prime example. Normally they go unnoticed, but they display fascinating patterns of behavior. For example, they obtain body heat from the sun by basking and appear to regulate their temperature by shutting in and out of the sun.

The function of basking has traditionally been assumed to be thermoregulation. Many investigations have been conducted under this assumption (Heath 1964; Hutchison 1979). But this standard explanation does not sufficiently account for some recent observations of basking turtles.

Why do turtles' body core temperatures increase as their basking time increases? True, dark-colored objects (such as turtle shells) increase in temperature when left in sunlight. But this principle of physics does not fully explain observed drastic elevations in core temperatures. After all, true ectothermic thermoregulation implies maintenance of a body temperature commensurate with that of the environment, give or take a few degrees.

Why is basking behavior so variable? It is replete with body postures and ritualized behaviors. Some of these actions may be omitted or repeated during a given basking exercise, depending on an intricate interplay of physical and biological factors.

Why do two or three basking turtles sometimes pile atop one another? They do this even when basking sites are numerous and unoccupied. While piled, some individuals face perpendicular to the sun; others lie parallel to the light rays. It would seem that such behavior would attract potential predators and thus be much too hazardous. Furthermore, precise thermoregulation is virtually impossible for piled turtles. Only the turtle on top can receive sunlight and convert it to heat.

Another significant question: why don't all aquatic turtles bask? Why evolve such a method of temperature control when the chances of predation are great? Perhaps the major adaptive advantage of basking is not thermoregulation.

This article examines the basking postures of captive eastern painted turtles exposed to two different sources of illumination and three types of substrates. The possible ecological and evolutionary significance of these behaviors is then discussed.

Materials and Methods

Six field-collected eastern painted turtles (*Chrysemys picta picta*) were marked with adhesive tape according to a system devised by my middle school students. These were maintained indoors throughout the Spring of 1980 and Fall of 1981 in a glass tank (90 × 90 × 31 cm). Inclination of the tank was about 15°, establishing

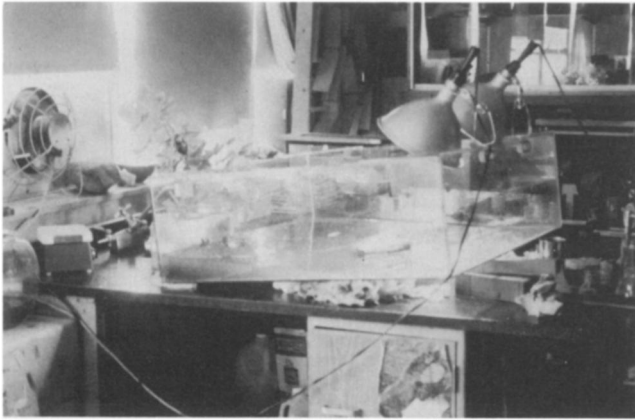


FIGURE 1. Laboratory tank and apparatus showing positions of floodlamps. Photo was taken in late afternoon after observations for that day were completed. Note the three types of substrates in the tank, and the presence of both shades and curtains to eliminate natural light during tests. No significant differences in basking patterns were noted when the tank was located in a windowless room. All photos by the author.

thermal and aquatic gradients. The dry portion was next to lamps mounted on the east side of the tank, away from the windows (fig. 1). Maximum water depth was 9 cm. Water was changed once a week. Turtles were permitted to acclimatize to this environment for five weeks prior to testing. During this time their body temperatures (T_B) were frequently obtained after atmospheric (i.e., out-of-water) basking to establish thermal histories for later comparison.

Turtles were exposed to white flood lamps and to an infrared heat lamp to determine basking times under these two conditions. Opaque shades eliminated natural light. Freshly collected sphagnum (*Sphagnum sp.*), a rock, and two wooden blocks served as basking sites. The body temperature of each turtle was obtained within 15 seconds of leaving a basking site through insertion of a Schultheis rapid-registering reptilian thermometer 5 cm into its cloaca. (These thermometers are available from Schultheis and Son, Inc., Crossover Road, P.O. Box 398, Arkville, NY 12406.) Because

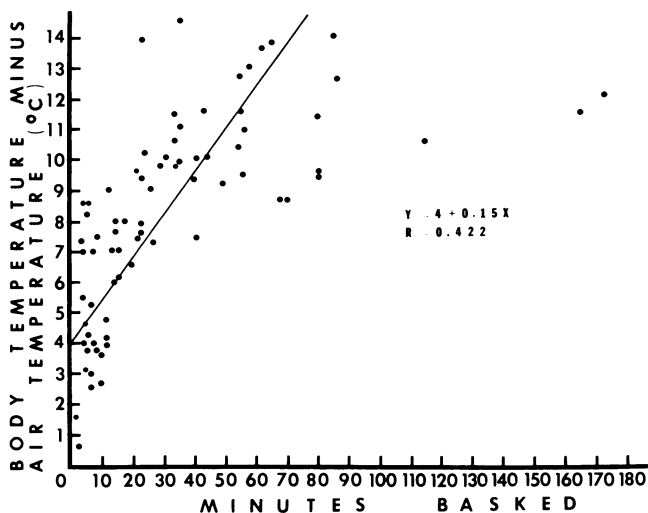


FIGURE 2A. Relationship between time spent basking and the difference between body temperature. $N=75$.

several turtles sometimes basked simultaneously, the exit of one often disturbed others sufficiently to cause their exit as well, so the temperatures of some animals could not be recorded. Measurement of cloacal temperature was followed by temperature recordings of the water, air, rock, wooden blocks, and sphagnum. Records of all of these ambient temperatures (T_A) were not always obtainable, however, since some turtles remained on basking sites as others exited.

We observed two female and four male turtles during our indoor studies. Data obtained from these laboratory investigations were later compared to observations of basking turtles in their natural outdoor habitats.

Laboratory Results

Temperature Relationships. Whereas no relationship between the size of the animal and cloacal temperature appeared to exist, a significant positive association was evident: the more time spent basking, the greater the difference between body temperature and substrate, air and water temperature (fig. 2).

Behavioral observations were divided into: a) postures during basking; b) type of substrate selected; and c) piling behavior.

Basking Postures. Auth (1975) and Litwin (1976) studied postures during basking. Litwin based her description of chelonian basking behavior on field observations of painted turtles. She divided such behavior into three phases: pre-bask, bask, and post-bask. A comparison of my laboratory observations with her field results for each phase is found in table 1.

Turtle basking behavior can be quite variable and complex. In table 1 I have not included those behaviors (such as kicking and face-rubbing) which occurred infrequently during my investigation. Certain postures may be omitted or repeated during an individual procedure.

Substrate Type. Of 110 basking events with both T_B and T_A recorded, 51 (46%) occurred on sphagnum,

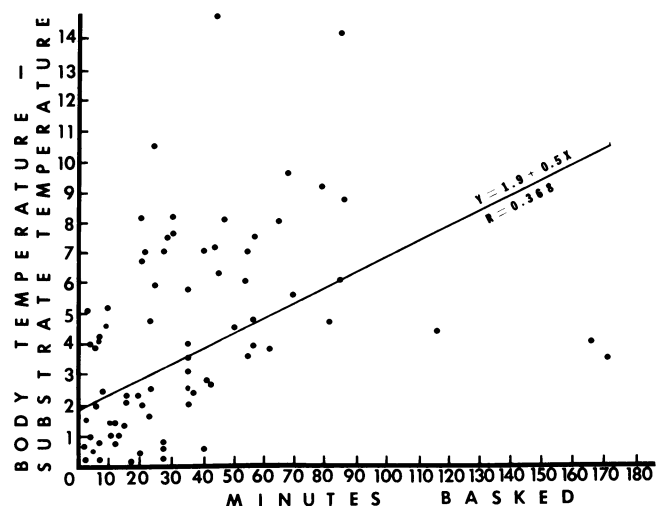


FIGURE 2B. Correlation of the difference between body temperature, substrate temperature, and air temperature. $N=75$.

TABLE 1. Basking Scenario Observed in the Laboratory As Compared to That Reported by Litwin (1976) in the Field.

Phase	Period	Behaviors	Source
Pre-bask		Emergence from water, head up, front limbs grasping substrate	Zipko and Litwin
Bask	Start	All limbs and tail extended, head up, possible mouth gapes; <i>or</i> All limbs extended, head up, and tail withdrawn, possible mouth gapes; <i>or</i> Hind limbs extended, with or without tail extension, head up, front limbs grasping substrate, possible mouth gapes; <i>or</i> One front leg stretched, head withdrawn, digits fanned, face wipe.	Zipko
		Animal oriented along longitudinal axis of substrate, front limbs grasping it, head up, with stretched tail and hind limbs, legs held vertically or horizontally, digits fanned; <i>or</i> Stretched tail, hind limbs held horizontally or vertically at angle to body, digits fanned; sometimes simultaneous stretch of both front limbs, digits fanned.	Litwin
	Middle	Head up, even with carapace or partly withdrawn, possible mouth gapes, hind limbs may be held back horizontally or vertically, digits fanned, front limbs extended, tail extended or withdrawn; <i>or</i> Head in one of same three positions, possible mouth gapes, hind leg(s) extended, with or without digits fanned, front limbs and tail withdrawn or extended; <i>or</i> Head in one of same three positions, possible mouth gapes, two limbs extended in one of four combinations, tail extended or withdrawn; <i>or</i> Animal lies flat on substrate, head partly or completely withdrawn, all limbs and tail withdrawn.	Zipko
		Head either partly withdrawn, extended at carapace height, or stretched upward, possible mouth gapes or biting directed toward congeners, front limbs totally withdrawn, hind legs stretched back, tail stretched; <i>or</i> Front limbs grasp substrate, hind legs and tail withdrawn.	Litwin
	Final	Total withdrawal of tail and all limbs, head is partly or totally withdrawn.	Litwin
Post-bask		Sudden turn and exit toward water; <i>or</i> Animal turns toward water and remains on substrate flat, then exits, sometimes places head in water before leaving.	Zipko
		Hind-limb kicking, restlessness, eye-rubs and plastron-rubs.	Litwin

27 (25%) on the rock, and 32 (29%) on wood. Neither turtle size nor sex appeared to influence substrate selection.

In the laboratory, little shifting occurred from one basking site to another when compared to the number of basks. While painted turtles moved from rock to wood more frequently under white light, they shifted from rock to sphagnum more often under infrared light.

Piling Behavior. A possible influence on site selection during this study was the tendency by some turtles to initiate basking, while other individuals basked only after one or two others had assumed their basking positions. This behavioral trait often resulted in a decreasing choice of basking sites for some turtles; hence they were frequently inclined to climb on the carapaces (upper shells) of the other basking turtles, sometimes even when basking sites were not limiting (fig. 3).

Boyer (1965) recognized a strong tendency in emydid turtles to search for higher elevations while basking.

He noted that, on level basking sites, this tendency was manifested by climbing on other turtles. He also implied that the tendency to attain greater elevation superseded the need to thermoregulate, because some turtles climbed from sun to shade along a basking site.

Piling occurred 42 (18%) times out of 229 basks during my study. Piling involves at least one turtle resting the anterior portion of its plastron (lower shell) on the posterior portion of another's carapace (fig. 4).

Litwin (1976) reported piling during intervals of both low and high turtle densities. It therefore does not seem to be a function of lack of basking locations. Bury and Wolfheim (1973), Waters (1974), and Auth (1975) claim that piling is done on preferred basking sites. Hennemann's (1979) data on captive basking juvenile suwannee terrapins (*Chrysemys concinna*) support this hypothesis, as do my own observations. Piling generally occurred either on rock or wood when few other animals, if any, were attempting to bask (fig. 5). It

FIGURE 3. Initial stage in piling incident shows "Doctor" immediately assuming basking position atop two other turtles after climbing upon the rock. Adhesive tape marking system had no discernible effect on normal basking behavior. Tape wore off with time.

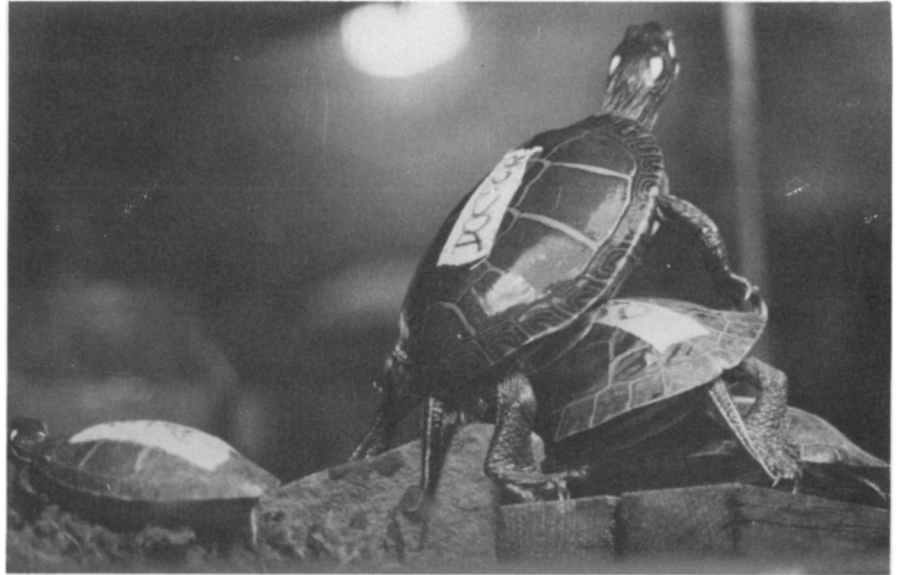


FIGURE 4. Piled turtles on sphagnum. Note the limbs extending from the turtle on the left.

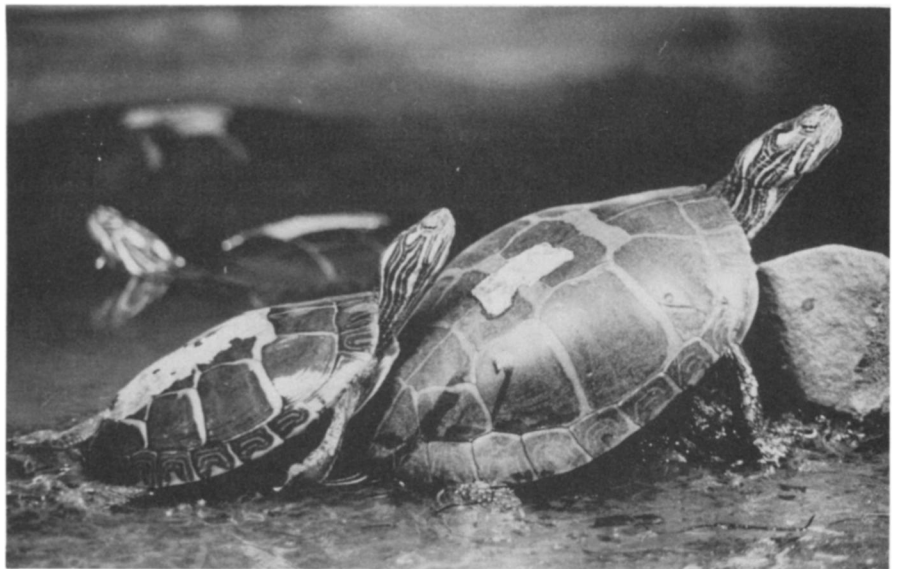
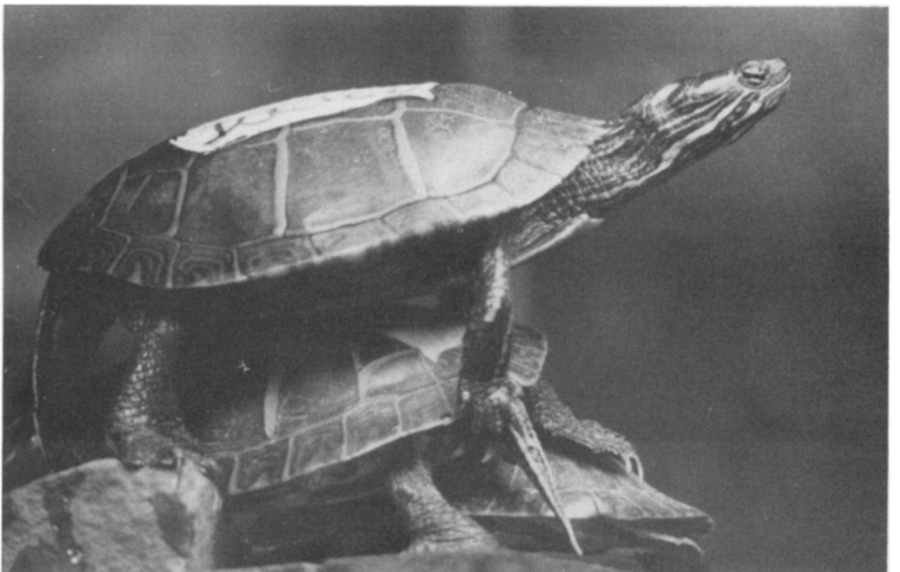


FIGURE 5. A pile of three males, with the bottom animal on wood. These are the same turtles as shown in figure 3.



would seem, then, that piling must be adaptive for some reason other than just thermoregulation.

Field Results

Although field observations verify our laboratory results, we did not observe field piling to the extent reported by other investigators. The sequence of basking postures, however, was basically the same as that found indoors.

Possible Significance of Piling

Our observations suggest no relationship between piling, number of turtles, limited basking sites, and time spent basking. Of 37 basking events that involved piling and which did not result in the lower turtle forcing the upper one(s) to exit, 13 (35%) of the lower turtles had been basking one to 20 minutes prior to the onset of piling, 12 (32%) had basked between 21 and 60 minutes, and 12 had basked between 61 and 190 minutes. It would appear that piling is equally tolerated by short- and long-term baskers.

Both Boyer (1965) and I found that piled painted turtles abandoned their basking sites with much less provocation than when they were not piled. Based on these findings, piling may have some social function, such as better warning against predators. Hennemann (1979) speculated that piling allows a turtle to increase its T_B from a cool, sometimes wet substrate (to which heat is rapidly lost from the body) onto the warm shell of another individual.

But these explanations also seem inadequate. Although a slight disturbance causes some piled turtles to scramble into water, the lower animals often remain. Boyer (1965) reported that the remaining animals are those that had been basking the longest. My data agree with this. Rarely did all the turtles leave. When they did, they did not exit simultaneously. Such observations would tend to negate any predator-avoidance advantage for the bottom turtle(s). Radiant energy uptake by such individuals, moreover, is drastically reduced during piling (Boyer 1965). While piling benefits those turtles at the top, it sometimes confers little adaptive benefit to the lower animals.

An observation of interest is that piles are often comprised of turtles of only one sex. Perhaps turtles in such congregations are competing for heat, thus affecting each other's sexual fitness, since reproductive events for ectotherms hinge critically on the presence of heat. Turtles on top of piles may reduce the rate of gonadal recrudescence among those on the bottom.

Basking Postures and Temperature

My turtles either repeated many postures or maintained the same ones over long periods (fig. 6). Yet, regardless of the variety of postures displayed, cloacal

temperatures increased with time spent basking. Behavioral plasticity of basking postures apparently did not enable turtles to maintain their T_B 's at levels commensurate with T_A . Kenyon (1925), Cagle (1950), and Gatten (1974) suggested that turtles bask to raise T_B above T_A for the successful completion of various metabolic processes such as digestion. Yet I often observed captive *Chrysemys* basking while in a post-absorptive state, having not fed for a week.

A diverse behavioral repertoire may suggest a much greater adaptive significance than has been realized. This view is further supported by observations of piling.

Adaptive Significance of Basking

Although basking is a thermal phenomenon, with heat gain as its proximal advantage, its ultimate purpose probably is not thermoregulation. Pritchard and Greenwood (1968) thought basking may assist the body to produce vitamin D. Many authors have suggested integumentary desiccation as a major purpose. Cagle (1950) suggested that periodic drying may be required to rid the shell and skin of parasites, especially since turtles lack integumentary adaptations for aquatic existence, i.e., mucous glands (Boyer 1965). Captive turtles have developed plastral inflammations when not provided with basking stations (Cagle 1950; personal observation). Edgren, Edgren, and Tiffany (1953) and Neill and Allen (1954) found pronounced deterioration of the shells and underlying tissues due to algal growths. Boyer (1965) noted that red-eared sliders (*Pseudemys scripta*) developed fungal infections in both carapace and plastron when he maintained them without providing basking sites. He also implied that digit-fanning and leg-extensions may dry the limbs.

Proctor (1958) reported that two algae, *Basiacladia chelonum* and *B. crassa*, often thrive on the carapaces of nearly all mature aquatic turtles endemic to North America. The exceptions are the soft-shelled turtle (*Trionyx*) and turtles of the genus *Clemmys* (including the spotted turtle). Proctor related the differing quantities of algae on different turtles to the physical characteristics of their epidermal laminae. These algae were more abundant on turtles with rough carapaces comprised of large, flexible, loosely joined epidermal cells such as snapping turtles (*Chelydra serpentina*). These cells in emydids are closely compacted and rigidly set into individual layers that are thick, such as in *Chrysemys*. The cells adhere tightly to one another, and the laminal surface is relatively smooth.

Proctor (1958) likewise stated that both algae were shown to survive frequent desiccatory periods similar in extent to those associated with basking. They were also shown to withstand long intervals of darkness while the turtles were hibernating. The continued growth of these algae on kinosternids such as musk turtles (*Sternotherus odoratus*) and chelydrids (snap-

ping turtles) is encouraged by the slow, gradual molting process in emydids. Although *Basiacladia* attach less readily to the longer-basking emydids, established algal filaments grow at a faster rate than those on kinosternids or cheydrids. This is due to the absence of a burrowing habit in emydids which characterizes the other two families (Proctor 1958).

McAuliffe (1977) compared frequencies of blood parasites (hemogregarines) infecting three turtle species with behavioral patterns of these turtles, particularly basking. Blood-sucking leeches (*Placobdella parasitica*) are thought to be the vectors for the hemogregarines. The parasitemia levels of the vectors were significantly less in western painted turtles (*C. p. bellii*) and Blanding's turtles (*Emydoidea blandingii*) than in *Chelydra*. He attributed this to differences in basking behavior, noting that *Chrysemys* and *Emydoidea* generally bask atmospherically while *Chelydra* mostly basks in water.

Yet Obbard and Brooks (1979) found atmospheric basking to occur in *Chelydra*. These investigators speculated that *Chelydra* normally bask atmospherically more often than had been previously believed. Their opinion was shared by Cagle (1950) and corroborated by my own observations. McAuliffe (1977) noted that leeches parasitizing *Chelydra* were often gorged with blood and yet they remained attached, establishing large colonies. This would not be expected to occur in atmospheric baskers, where leeches would desiccate.

Evolution of Basking

Algae increase rapidly on *Chrysemys* during May and June. This might be due to more favorable light conditions for algal growth as semiaquatic turtles increase their activity levels during late spring. Such algal concentrations would be reduced the most by shedding the

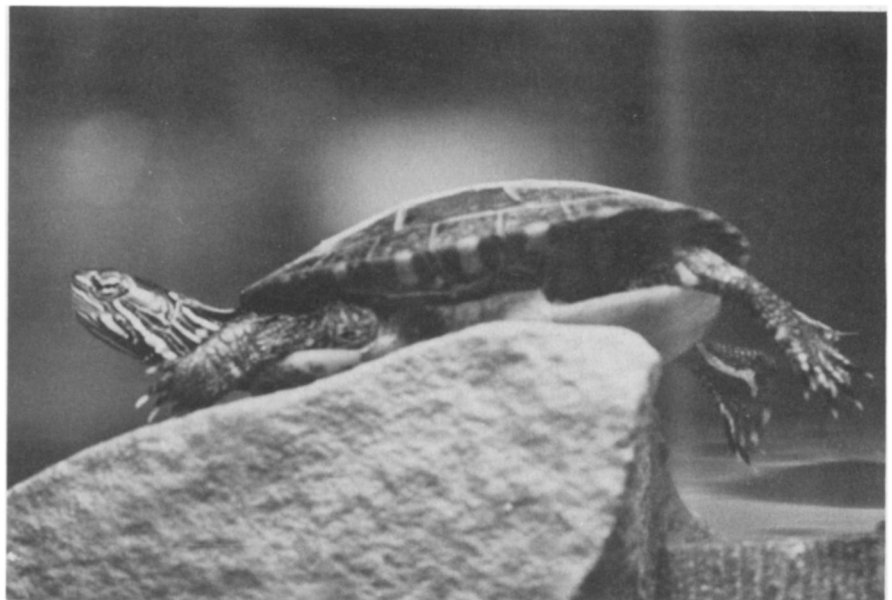
epidermal laminae, which in turn would be promoted by carapacial drying. Corroboration of this hypothesis comes from reports that *Chrysemys* bask mainly during spring and early summer (Bayless 1975).

Such seasonal changes in a turtle's environment, along with its behavioral responses to those changes, may offer a clue to the evolution of the basking habit. The bulk of the fossil evidence indicates that turtles originated in marshes from cotylosaurian ancestors during the Triassic (Hutchison 1979). The development of a mild climate during Carboniferous time may have favored the evolution of behavioral thermoregulation in certain reptilian stocks. This may have permitted the basking habit to become established in turtles 110 million years later.

Since both turtles and green algae such as *Basiacladia* are ancient groups, certain algae and turtles may have evolved symbiotic relationships. The adaptive radiation of these relationships may have been dependent upon the habitat preferences of the turtles as they likewise diversified. *Basiacladia* could have shifted from inanimate substrates to turtle shells by means of flagellated spores or other spore lodgment. Such means of dispersal still occurs with *Cladophora* and *Rhizoclonium* algae, although these genera are normally not ectoparasitic on turtles.

As turtles radiated into various habitats, some of which contained *Basiacladia* thriving on inanimate substrates, different combinations of genetic and ecological factors may have caused selection to favor development of different turtle shells and shedding rates. Ability to survive desiccation would have presumably evolved in the alga prior to this period as inanimate niches became available. The morphological and physiological evolution of turtle shells could not have been affected by the presence of algae. This lack of influence is due to the probability that many turtle species would have

FIGURE 6. Starting-bask posture shows partly extended forelimbs while hind legs are extended at angle to body.



otherwise evolved similar morphological and/or behavioral responses to algal colonization at that time. This would have been adaptively disadvantageous to the algae because all turtle "niches" would be alike. Turtle evolution would have also been hindered by this due to increases in competition and predation.

Natural selection, therefore, most likely favored algal infestation only after a diversity of turtle niches opened up. While many turtles evolved a response to the presence of algae by burrowing in sediment beneath the water surface, others spent much time near the surface and, due to previously developed behavioral patterns, evolved a basking habit that was initially aquatic, then atmospheric. Some algae that were highly tolerant to drying still prospered on the shells of the atmospheric baskers, so selection favored longer basking intervals in these turtles. Later, as the hemogregarine life cycle evolved to favor transmission by the *Placobdella* vector, turtles responded to these ectoparasites in a manner similar to their responses to algal infestation. Turtles either burrowed, or moved out of the water temporarily to bask until the leeches were forced to detach. Thus, in view of the apparent requirement by basking turtles for greater heat input for integumentary drying, the evolution of tail, limb, and head extensions and limb-kicking while basking is not surprising.

Indeed, limb-stretching and digit-fanning in emydids may have evolved partly as a result of piling so that turtles could maintain their places on the basking site while exposing maximum surface area to sunlight. This explanation would not hold true for turtles that stretch their limbs while basking atmospherically yet never pile, such as *Chelydra*. Evolution of limb extensions in these turtles presumably developed from the need to acquire more heat and thoroughly dry the integument.

Conclusion

The basking emydid turtles have become widespread. Their 31 genera constitute the largest, most diverse family of turtles (Hutchison 1979). I believe this successful radiation of emydids is due, in large part, to their basking habit which, although originally thermoregulatory, has also become useful in temporarily elevating their body temperatures sufficiently for ectoparasitic regulation via integumentary and carapacial desiccation.

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