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Notes on Comparative Tolerance of Some Iowa Turtles to Oxygen Deficiency (Hypoxia)[1]

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Abstract. Six species of Iowa turtles (including pharyngeal water-pumpers and non-pumpers) were tested for resistance to anoxia. Five species of juveniles were included in the series. With the exception of *Trionyx,* adult aquatic turtles tolerated hypoxia longer than juveniles of the same species. Some terrestrial species were as tolerant as some aquatic species. Maximum tolerance time submerged (18° to 19°C) was 56 hours for an equatic species, *Chrysemys picta,* whereas that of a terrestrial species, *Terrapene ornata,* was 12 hours.

Several species of turtles have been observed, while resting quietly for prolonged periods under water, to pump the pharynx by a vigorous, rhythmic contraction of throat muscles. We have observed this behavior in *Trionyx ferox* and *Trionyx muticus,* with the pulsations occurring from 16 to 23 cycles per minute at 25°C. A different habit is found in other aquatic turtles, namely an irregular and occasional gulping which becomes infrequent after prolonged submergence (observed in *Chrysemys picta, Emys blandingi,* and *Chelydra serpentina*). Some speculation about the function of pharyngeal pulsation has been published, but few experiments have been completed. Carr (1) suggests that not only do aquatic turtles obtain additional oxygen from water by means of their highly vascular pharyngeal cavities, but also that soft-shelled turtles, *Trionyx,* are more dependent upon aquatic respiration than other turtles. He implies that the more obvious pharyngeal pumping of these turtles is more efficient than the gulping of other turtles. Gage and Gage (5) state that by maintaining a circulation of water in the pharynx, soft-shelled turtles are permitted to remain under water several hours. Carr (1) states it more emphatically: "Soft-shells are able to remain submerged for long periods of time—several hours, if not indefinitely—owing to their exceptional capacity for pharyngeal (and probably for anal) respiration."

The present study was initiated because there was little specific information on underwater tolerance times to compare with

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the supposed differences in physiological mechanisms found in the pharyngeal pumpers, an din the non-pumpers. Our experiments were designed to show whether soft-shelled turtles (pharyngeal pumpers) were more able to tolerate hypoxia than other kinds of turtles.

Methods

Adult turtles, representing six species, and juveniles, representing five species, were tested in the present study. All but two species were collected in Iowa by the senior author. These were adult painted turtles (*Chrysemys picta*) and juvenile red-eared turtles (*Pseudemys scripta elegans*) obtained from commercial sources. Identification was based on Conant (2).

The animals were confined individually in wire cages about 6 inches beneath the water surface in 8-liter containers. As a control experiment individuals of *Chrysemys picta* were submerged in tightly sealed vessels containing previously boiled water, thereby precluding any contact between atmospheric air and water. Tap water (16 to 26°C) was used in all testing. An additional study to determine the effect of cold water on juveniles of *Pseudemys scripta* was also included. All animals appeared to be in good health at the time of the experiments.

The degree of hypoxia was determined by eye reflexes, reflexes of the head and limb, and righting reflexes. When response to stimulus was slight or lacking, the animal was removed from the water and the experiment terminated. Each animal usually recovered when exposed to air; respiratory movements began immediately or within five minutes. A few specimens remained moribund for several hours (one for 5.5 hours), but recovery still occurred.

Results

Adult turtles showed acute hypoxia after from 2 to 93 hours of submergence; the comparative time for juveniles of the same species was from 2 to 17 hours. For adult turtles the mean tolerance to submergence (in hours) was: *Trionyx muticus* 2 (one specimen); *Terrapene carolina* 6; *Terrapene ornata* 12; *Pseudemys scripta* 12; *Chelydra serpentina* 27; *Chrysemys picta* 56. In the juveniles, the mean tolerance (in hours) for each species was: *G. pseudogeographica* 6; *Pseudemys scripta* 8; *Chrysemys picta* 13; *Chelydra serpentina* 13; *Trionyx spinifera* 17. In general, adult turtles showed longer tolerance times than corresponding juveniles of the same species. However, a freshly captured adult *Trionyx muticus* survived only 2 hours of submergence while juveniles of the same genus tolerated 17 hours of submergence. Probably a higher tolerance time for adult soft-shell is to be expected. It should be noted here that only one adult specimen of *Trionyx* was tested in this study.

In a single experiment, hatchlings of *Pseudemys scripta* were submerged in cold water (10 ± 2°C). These specimens tolerated submergence for an average of 12.3 hours, or approximately 1.6 times longer than controls in warmer water (24 to 25°C).

Discussion

The results of these experiments indicate that aquatic turtles of several species may vary as much as 54 hours in their tolerance times to hypoxia, and that some terrestrial species are as tolerant as some aquatic species. The ability to tolerate oxygen deficiency indicates that an animal can accrue an oxygen debt (Prosser) (8) or a high level of tissue carbon dioxide (McCutcheon) (6). Apparently, we have observed in this experiment a variation in the ability of turtle species to build up an oxygen debt. This ability did not appear to be a function of the size of the adult species. The size of the young did not vary enough to warrant the same comparison.

The mechanism behind a greater tolerance to hypoxia of turtles compared to other reptiles has been attributed to the following factors by Shaw and Baldwin (10): (1) an ability to ventilate the lungs thoroughly, (2) a low "unloading tension" of hemoglobin, and (3) unusually low oxygen requirements. These mechanisms appear to be supplemented while a turtle is under water. Recent evidence demonstrates that physiological systems of turtles permit them to obtain oxygen from water, as shown by Root (9) using *Sternotherous odoratus* (through pharynx and skin) and by Dunson (3) using *Trionyx aspera* (through pharyngeal, cloacal and dermal areas). Some evidence that *Chrysemys* has this ability was reflected in these studies. Submerged animals with an air surface had longer tolerance times than those lacking an air surface. Musacchia (7) made the same observation of this species. Also, our comparative data of the various species support the concept of aquatic respiration in soft-shelled turtles. Juvenile *Trionyx spinifera,* which show frequent throat pulsations, tolerated submergence longer than other juvenile species.

The tolerance times in our series for *Chrysemys picta* (37 to 76 hours at 18 to 20°C) without air surface correspond closely with those observed by Musacchia (25 to 80 hours at 20°C) under the same experimental conditions. Likewise the tolerance of *Pseudemys scripta* in cold water was increased as was the case in his study of *Chrysemys picta.* The work of Gaumer (4) showed that the blood of *Terrapene* had higher affinity for oxygen than did an aquatic species (*Pseudemys*), partly explaining the unexpectedly high tolerance to hypoxia of our *Terrapene* (12 hours).

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Effect of Irradiation On Nissl Granules In Rat Spinal Cord Neurons—A Pilot Study[1]

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Abstract. Literature concerning the structure and function of Nissl granules and the effect of irradiation on the central nervous system is reviewed. Four groups of rats were irradiated in the lower thoracic spinal region, using doses of 600 r, 900 r, 1200 r, and 4200 r respectively. Higher doses of the irradiation caused depletion of the Nissl granules and other effects on the nerve cells. Increasing chromatolysis was found with increasing doses of irradiation. These findings warrant further study.

The existence of Nissl granules in nerve cells was first reported in 1894 (1). Since then they have been the subject of much controversy. At first the dispute concerned the very existence of these granules. Authors disagreed on whether Nissl granules were an actual part of the nerve cell cytoplasm (2,3,4) or whether they were just artifacts produced by preparation of the tissue for study (5,6,7,8). However, modern technics of freezing-drying (3), phase contrast (9), and electron microscopy (10,11,12,13) have demonstrated their presence, and the majority of present-

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