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Body condition of hatchling alligator snapping turtles (*Macrochelys temminickii*) confiscated from the illegal international wildlife trade.

Malcolm L. McCallum[1]*, Stanley E. Trauth[2], Benjamin A. Wheeler[3] and Richard L. Shelton[4]

Abstract. The illegal international wildlife trade is a serious problem for the global community. Turtles are one of the regularly traded species. We collected data off of over 200 hatchling Alligator Snapping Turtles that the US Fish and Wildlife Service confiscated in route to China. Hatchlings were in various stages of metabolic bone disease. Generally, the degree of metabolic bone disease was inversely related to the standard carapace length, standard carapace width, carapace height and body mass. We believe that the condition of these hatchlings developed due to poor care provided during shipping by the illegal traders.

Keywords. Alligator Snapping Turtle, black market, Illegal wildlife trade, *Macrochelys temminickii*, poaching, wildlife.

Introduction

There is significant economic incentive for illegal trade of wildlife on an international scale (Barnes and Jager, 1995; Lee, 1996; Tisdell, 2005) and regulations are often ineffective (Shepherd and Nijman, 2008), so this activity is of serious concern to government and wildlife officials (Alacs and Georges, 2008). Illegal trade of wildlife serves as a source of human and wildlife diseases (Yiming and Dianmo, 1998; Bell, Roberton, and Hunter, 2004; Gómez and Anguirre, 2008) and parasites (Burridge, 2007), provides opportunities to introduce invasive and exotic species (Carrete and Tella, 2008; Sodhi et al., 2004), and aggravates at-risk species' endangerment (Lee, 1996; Walpole et al., 2001). Turtles are among the popular targets of the illegal international wildlife trade (Thorbjarnarson, 2001; Ceballos and Fitzgerald, 2004; Nijman and Shepherd, 2007).

The health of animals that wildlife officials confiscate during crackdowns on the illegal international wildlife industry remains poorly recorded. Most of our information is based on anecdotal observations or comments (see Karesh, 1995; Encalada et al., 1994; Lau et al., No date). Illegal wildlife smugglers often subject animals to poor hygiene, starvation, and other mistreatment (Clark et al., 2008). Further, the smuggled animals frequently harbour parasites and diseases (Bailey, 2000; Kilbourn et al., 2003; Lampen et al., 2005; Superina et al., 2009). Little information exists about the health status of confiscated turtles, although we speculate that they are likewise mistreated. In a reintroduction study involving confiscated Egyptian Tortoises (*Testudo kleinmanni*) only 20 of ~200 surviving turtles were healthy enough (i.e., no clinical signs of disease) to reintroduce to the wild after an intensive clinical health screening (Alterio et al., 1999). Another study determined that it took 8-24 months of intensive veterinary care before all nine confiscated Bornean River Turtles (*Orlitia borneensis*) recovered from a complex of serious shell necrosis, bacterial infections and haemogregarine parasite infestation (Knotkova et al., 2005). After 8 mo., only 1/3 of these turtles had recovered. They mentioned the confiscation of hundreds of Bornean River Turtles without indicating what happened to the rest.

Despite several recent studies (Hiler et al., 2006; Rauschenberger et al., 2004) that advanced our knowledge regarding the biology of the Alligator Snapping Turtle, (Harrel et al., 1996; Trauth et al., 1998; Tucker and Sloan, 1997), substantial information is still lacking, especially in the areas of hatchling development, ecology, and pathology (see Reed et al., 2002; Upton et al., 1992; McAllister et al., 1995). This gap in the natural history of these animals is critical

1 117 Linda Lane, Texarkana, Texas 75501, USA; e-mail: malcolm.mccallum@herpconbio.org
2 Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467; e-mail: strauth@astate.edu
3 Math and Science Division, University of Arkansas Community College at Batesville, 2005 White Drive, Batesville, Arkansas 72501; e-mail: benjamin.wheeler@uaccb.edu
4 National Fish Hatchery, P.O. Box 160, Mammoth Spring, Arkansas 72554; e-mail: richard_shelton@fws.gov
* Corresponding author.

Table 1. Mean standard carapace lengths, shell widths, heights, and masses of Alligator Snapping Turtles (*Macrochelys temminickii*) at three stages of metabolic bone disease (MBD). Standard Carapace Length = SCL, Standard Carapace Width = SCW, Shell Height = SH, Body Mass = BM.

	Advanced MBD	**Early MBD**	**No MBD**
Total turtles in group	18	117	84
Mean SCL (mm) (overall = 35.41, SE = 0.12)	33.96 (SE = 0.41)	35.20 (SE = 0.17)	36.02 (SE = 0.16)
Mean SCW (mm) (overall = 32.83, SE = 0.11)	30.63 (SE = 039)	32.62 (SE = 0.14)	33.61 (SE = 0.14)
Mean SH (mm) (overall = 17.68, SE = 0.11)	16.89 (SE =0.29)	17.60 (SE = 0.19)	17.96 (SE = 0.09)
Mean BM (g) (overall = 14.30, SE = 0.12)	13.22 (SE =0.44)	14.09 (SD = 0.16)	14.84 (SE = 0.19)
Tukey interval for SCL of No MBD vs.	CI = -3080, -1.042	CI = -1.376, -0.254	--
Tukey interval for SCL of early MBD vs.	CI = -2.239, -0.253	--	CI = -1.376, -0.254
Tukey interval for SCW of No MBD vs.	CI = -1.485, -0.492	CI = -3.875, -2.072	--
Tukey interval for SCW of early MBD vs.	CI = -2.864, -1.107	--	CI = -3.875, -2.072
Tukey interval for SH of No MBD vs.	CI = -0.875, -0.196	CI = -1.685, -0.453	--
Tukey interval for SH of early MBD vs.	CI = -1.134, 0.067	--	CI = -1.685, -0.453
Tukey interval for BM of No MBD vs.	CI = -2.696, -0.531	CI = -1.342, -0.150	--
Tukey interval for BM of early MBD vs.	CI = -1.923, 0.188	--	CI = -1.342, -0.150
Does SCL predict BM?	$r^2 = 0.075$, P = 0.186	$r^2 = 0.241$, P < 0.001	$r^2 = 0.259$, P < 0.001
Does SCW predict BM?	$r^2 = 30.5$, P = 0.004	$r^2 = 0.275$, P < 0.001	$r^2 = 0.271$, P < 0.001
Does SH predict BM?	$r^2 = 0.047$, P = 0.298	$r^2 = 0.135$, P < 0.001	$r^2 = 0.352$, P < 0.001

when undertaking conservation efforts (Bury, 2006; McCallum and McCallum, 2006).

One of the more problematic disorders experienced in captive turtles is metabolic bone disease (Palika, 1998). This disorder manifests as reduced retention of calcium salts in the bone matrix leading to a rickets-like condition. As the shell and bones become soft and pliable, the animal becomes lethargic and sedentary. This disorder may arise through lack of sufficient exposure to ultraviolet light needed to process vitamin D (Boyer, 1996); however, similar disturbances can arise from pathogens (Knotkova et al., 2005).

Metabolic bone disease is most common in rapidly growing individuals because they lack the vast reservoir of bone calcium normally present in adults (Boyer, 1996). It is avoidable by providing a source of ultraviolet (UV) light which catalyzes production of cholecalciferol in calcium metabolism (Boyer, 1996). Growth of turtles with metabolic bone disease is slower than for healthy turtles and shell abnormalities become more prevalent in afflicted turtles as growth continues (Boyer, 1996).

Hatchling carapace length of Alligator Snapping Turtles (*Macrochelys temminickii*) is typically 35.5 – 42.0 mm, and their mass is 14.2 – 20.1 g (Dobie, 1971; Drummond and Gordon, 1979; Grimpe, 1987). Newly hatched hatchery-reared Alligator Snapping Turtles exhibiting a condition termed "curly-tail" have a mean standard carapace length of 35.8 mm and a mass of 15.3 g, whereas normal individuals have a carapace length of 37.8 mm and mass of 15.97 g (McCallum and Trauth, 2000).

In 2001, the US Fish and Wildlife Service confiscated a large collection of hatchling Alligator Snapping Turtles that originated from Arkansas. We collected morphometric data from these confiscated turtles to characterize their condition.

Materials and Methods

The hatchling Alligator Snapping Turtles spent an extended (uncertain) time without care in packinghouses before confiscation. The Mammoth Spring National Fish Hatchery took possession of the hatchlings in early fall 2001. Many hatchlings had yolk sacs, and the plastral scutes of most were not fused over the umbilical scar. We measured the standard carapace length, carapace width, shell height, and obtained the mass of each hatchling.

We sorted hatchlings (n = 219) into three groups as follows: 1) advanced metabolic bone disease (n = 18), 2) early signs of metabolic bone disease (n = 117), and 3) no signs of disorder (n = 84). Individuals that were lethargic and sedentary, with extremely soft shells were placed in group 1. Subjects with shells that were somewhat flexible, but otherwise appeared active and healthy were placed in group 2. Turtles with normal hard shells were placed in group 3. Differences between groups were analyzed with analysis of variance with between-groups differences determined using a Tukey's pairwise comparisons test employing a 95% confidence interval (CI) (Neter et al., 1996).

Results

Nearly 61% of the confiscated turtles had signs of metabolic bone disease. We observed significant differences among the standard carapace lengths ($F = 13.43$, $df = 2$, $P < 0.001$), shell width ($F = 33.05$, $df = 2$, $P < 0.001$), height ($F = 3.63$, $df = 2$, $P = 0.028$), and mass ($F = 8.06$, $df = 2$, $P < 0.001$) of the three stages of metabolic bone disease (Table 1). The group without signs of metabolic bone disease had larger standard carapace lengths, standard carapace widths, carapace heights, and body masses than the groups with early signs and advanced signs of metabolic bone disease (Table 1). The group with early signs of metabolic bone disease had larger standard carapace length, standard carapace width, than the group with advanced stages (Table 1). However, there were no differences between the body masses or shell heights of the groups with advanced and early stages of metabolic bone disease (Table 1).

Although turtles without signs and those showing early stages of metabolic bone disease had positive linear associations between standard carapace length and mass, the advanced metabolic bone disease group did not have this pattern (Table 1). The association between shell height and body mass in healthy hatchlings was a strong positive, linear relationship (Table 1). Hatchlings with early signs of metabolic bone disease exhibited a weakly positive linear relationship between shell height and body mass (Table 1). The advanced metabolic bone disease group showed no relationship between shell height and body mass (Table 1).

Shell width showed a strongly positive linear relationship with body mass in all three groups. A linear association between mass and standard carapace length ($r^2 = 0.272$, $P < 0.001$), width ($r^2 = 0.324$, $P < 0.001$), and height ($r^2 = 0.223$, $P < 0.001$) when all three groups were pooled.

Discussion

Most of the confiscated turtles displayed metabolic bone disease upon receipt, and we suspect that virtually all were under significant metabolic stress prior to our acquisition. Clearly the illegal shipping of hatchling Alligator Snapping Turtles did not involve much concern for the health of the animals. It is questionable whether these hatchlings would survive the trip overseas to their eventual destination. Undocumented rumor was that the turtles were on their way to China when confiscated (Anonymous, Pers. Comm.).

It appears that standard body dimensions and body mass decrease as metabolic bone disease increases in severity. Standard carapace lengths and masses of individuals that appeared healthy were comparable to those observed in healthy hatchlings by other investigators (Dobie, 1971; Drummond and Gordon, 1979; Grimpe, 1987; McCallum and Trauth, 2000). Both of these measurements became substantially smaller as symptoms increased in severity. It appears that shell width is most affected by metabolic bone disease in hatchling Alligator Snapping Turtles. Unfortunately, records of shell width – mass relationships in healthy alligator snapping turtle hatchlings are not readily available for comparison. Likewise, no large studies of hatchling growth in the wild or in captivity exist. Without these kinds of data at hand, it becomes paramount that this information be gathered to better evaluate the impacts of pathology and husbandry conditions on these maladies.

Information regarding the husbandry requirements of hatchling Alligator Snapping Turtles is largely limited to a non-peer reviewed literature (e.g., Austin's Turtle Page. Available from http://www.austinsturtlepage.com/Care/cs-allisnapper.htm [Accessed: 11 February 2011]; Snapping Turtles & Things http://www.chelydra.org/snapping_turtle_food_feeding.html [last accessed: 11 February 2011]; Snapping Turtle Care Sheet. Available from http://www.chelonia.org/Articles/chelydracare.htm [Accessed: 11 February 2011]). No previous scientific studies target the UV exposure needs of Alligator Snapping Turtles or detailed nutritional requirements. Whether the development of metabolic

bone disease arose due to unique requirements of Alligator Snapping Turtles or if this reflected the severe stress these hatchlings experienced before confiscation is unclear. Regardless, our observations follow on previous reports with other taxa making it clear that animals confiscated from the illegal international wildlife trade are generally in poor health due to mistreatment by those involved in this criminal activity. More proactive strategies are needed to prevent animals from entering the black market whether these involve establishment of competitive markets (Brown and Layton, 2001; Rivalan et al., 2007) or market reduction (Schneider, 2008) because if these animals enter the trade, they are likely to succumb to mistreatment.

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