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Mud Accumulation in Nesting Aquatic Turtles (Emydidae) in Illinois

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The red-eared slider (*Trachemys scripta elegans*) is a common and widely distributed turtle in North America (Conant and Collins, 1991; Ernst et al., 1994). This turtle is, nevertheless, subject to considerable exploitation in parts of its range (reviewed by Tucker and Moll, 1997). In some cases, harvesting of local stocks has affected local demographics (Warwick et al., 1990). Populations of sliders, and other turtles, are also adversely affected by other human disturbances including highways and roads (e.g., Ruby et al., 1994), fires (e.g., Bigham et al., 1965; Dodd et al., 1994), fences (Tucker and Filoramo, 1996), and other dangers (reviewed by Ernst, 1995).

Agricultural activities are also sources of mortality (Ernst, 1995) and injury (Saumure and Bider, 1998). Generally, mortality is due to encounters between turtles and agricultural equipment or due to habitat modification resulting from cultivation. However, the agricultural environment may also hamper normal life history activities to lesser degrees short of outright mortality.

For instance, Saumure and Bider (1998) found evidence of reduced recruitment and slower growth in populations of the wood turtle (*Clemmys insculpta*) that occur in agricultural settings compared to those occupying less disturbed habitats. Herein, we examine mud accumulation, a previously unrealized handicap suffered by aquatic turtles that enter agricultural fields to nest.

Methods. — We caught sliders (*Trachemys scripta elegans*) in June 1998 near Stump Lake in Jersey County, Illinois (see Tucker, 1997 for details), and a single painted turtle (*Chrysemys picta*) in June 1997 at Stump Lake.

We weighed turtles along with accumulated mud with a spring balance (nearest 10 g) in the field. Bladders of all turtles were emptied prior to weighing (Kinney et al., 1998) and all turtles were gravid when captured. Turtles were marked for later identification. Mud was removed by washing the turtles after we returned to the laboratory. We then reweighed the turtles (nearest 10 g) and measured straight-line plastron length (nearest mm) and maximum carapace length (nearest mm) for each female. Mass of accumulated mud was determined by subtract-

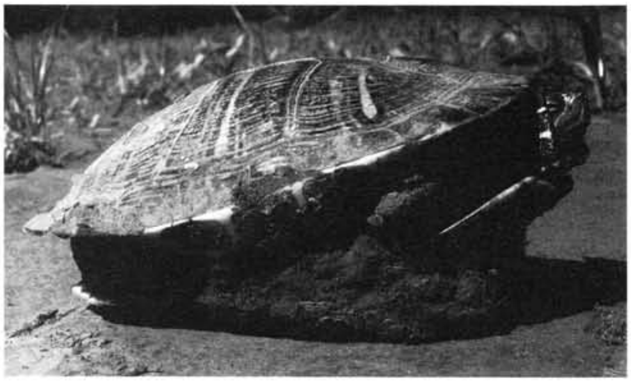

Figure 1. A female red-eared slider (*Trachemys scripta elegans*) with accumulated mud on the underside of the plastron (plastron length 206 mm).

Figure 2. A female painted turtle (*Chrysemys picta*) immobilized by a large wedge of accumulated mud (plastron length 146 mm).

ing mass determined in the laboratory from mass of turtle and mud measured in the field.

Oxytocin was used to induce oviposition (Ewert and Legler, 1978). Eggs were weighed with a Sartorius electronic balance to 0.01 g. Clutch mass was derived using the method of Tucker et al. (1998). Spent body mass was estimated by subtracting clutch mass from the female's gravid body mass. Relative clutch mass (RCM) was calculated by dividing clutch mass by spent body mass for each female. We returned the turtles to the original collecting area for release 48 hrs after inducing oviposition (Tucker et al., 1995). We used SAS for all statistical analyses (SAS Institute, 1988). Means were compared with the Wilcoxon signed rank test (Z); Spearman's correlation coefficient (Rho) was used to measure association among variables. Both are nonparametric procedures.

Results. — Overall, 539 gravid red-eared slider turtles were collected in 1998. We observed that turtles crossing rain-soaked, newly cultivated fields could accumulate mud on the plastron and carapace (Fig. 1). These field and weather conditions that lead to mud accumulation were prevalent only during a short period in June. Consequently, this study was limited to 21 red-eared slider turtles collected on two different days: 13 turtles on 6 June and 8 turtles collected on 9 June 1998. We also observed a painted turtle collected on 15 June 1997 that had heavy mud accumulation (Fig. 2).

Turtles collected on the two different days did not differ in the amount of accumulated mud ($Z = 1.16, p = 0.2456$), in gravid mass ($Z = 0.83, p = 0.4043$), in measures of reproductive output (egg mass: $Z = 0.04, p = 0.9711$ and clutch size: $Z = 1.46, p = 0.1442$), or in linear measures of female size (carapace length: $Z = 1.05, p = 0.2926$ and plastron length: $Z = 1.05, p = 0.2918$). Consequently, data for these two groups of turtles were combined for further analysis.

The 21 turtles collected were carrying large amounts of mud (Table 1). Mass of mud on the shells of these turtles averaged about 11% of the gravid mass of the turtles. Moreover, the turtles were carrying as much or more mass in mud as they were in clutch mass. The amount of mud being carried by individual turtles varied from as little as 10 g to as much as 680 g.

The amount of mud being carried by individual turtles did not co-vary with plastron length (Rho = -0.08, p = 0.7420). Consequently, small turtles might carry large amounts of mud, whereas large ones might be carrying small amounts. For instance, one relatively small turtle (gravid mass = 1150 g, plastron length = 184 mm) had accumulated 340 g of mud and was therefore carrying nearly 30% more weight than normal. Moreover, the turtle had a clutch mass of 76.8 g, but was carrying 4.4 times that mass in mud.

Discussion. — Clearly, accumulated mud can be energetically significant and in the sample that we examined actually exceeded clutch mass on average. Some of the turtles that we studied make nesting migrations of 1 km or more (Tucker, 1997). Such long nesting migrations are energetically costly (e.g., Congdon and Gatten, 1989) even without the added burden of accumulated mud.

The biological significance of the phenomenon that we report is not completely clear. Although an additional 11% in mass may be energetically significant, turtles can bear relatively large loads on their carapaces (up to 100% of body mass) with minimal effect on locomotion (Zani and Claussen, 1995; Marvin and Lutterschmidt, 1997; Wren et al., 1998). However, the mud accumulation that we report occurred on the plastron in a position that probably directly interferes with limb movements and locomotion.

Mud accumulation may only occur on a few days of the nesting season. The turtles that we studied only accumulated mud in fields that were newly cultivated, and then only for one or two days following rain events. However, nesting activity seems to be stimulated by rainfall (Tucker, 1997), so

Table 1. Accumulated mud, body size, and reproductive output for 21 red-eared sliders (*Trachemys scripta elegans*) collected while nesting in tilled agricultural fields in west-central Illinois on 6 and 9 June 1998. Gravid mass was measured after removing accumulated mud.

	Mean	SD	Min	Max
Plastron length (mm)	211	16	184	241
Carapace length (mm)	227	16	203	256
Gravid mass (g)	1690	340	1150	2290
Accumulated mud (g)	170	190	10	680
Clutch size (eggs)	14.5	2.7	9	18
Egg mass (g)	10.60	1.49	8.53	14.56
Clutch mass (g)	155.6	43.6	76.8	262.1

more turtles may be likely to nest during periods when mud accumulation is likely.

Moreover, mud accumulation only occurs when turtles cross loams, silt loams, or silty clay loams. Sandy soils do not accumulate on sliders in our study area. Regardless, if all other factors are equal, mud accumulation due to human agricultural practices will impair locomotion and increase the energy needed for nesting migrations compared to energy needs in sites where mud accumulation does not occur. The 11% average for accumulated mud vs. gravid mass that we found is similar to the percentage of gravid mass that bladder water accounted for in nesting *Chrysemys picta* (Kinney et al., 1998).

In extreme instances, mud accumulation may immobilize individual turtles. We encountered an example of this in the single painted turtle we observed (Fig. 2) who could not crawl but instead could only rotate slowly on the mass of mud that had built up under the plastron. This turtle weighed 500 g but was carrying an additional 280 g of mud. She later produced a clutch of 9 eggs that averaged 9.05 g in mass. Had we not found this turtle, it would have been particularly vulnerable to predators, exhaustion, or heat death so long as the mud continued to adhere to it.

It is important to note that all of the turtles that we studied were crossing fields in various wildlife refuges. These cultivated fields are publicly owned and farmed to provide increased forage for game species. Such practices are widespread on federal and state refuges, particularly in areas where waterfowl and upland game birds are present.

Our findings for *Trachemys scripta* and *Chrysemys picta* may have implications for other species and especially similar-sized species that might be targets of conservation programs. Agricultural activities used to promote game species may impact nontarget species (this study and Saumure and Bider, 1998). Such activities should be avoided by conservation area managers where turtle conservation is an important consideration.

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