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A Device For Separating Fecal Samples Of A Mollusc-Feeding Turtle, *Malaclemys terrapin*

Studies of chelonian food habits have employed five primary techniques for dietary analysis: (1) laboratory feeding trials, (2) field observation, (3) dissection of the digestive tract, (4) stomach flushing, and (5) fecal analysis. Each method possesses unique advantages and the method selected depends upon the nature of the study or the need for repeated sampling (Graham 1979; Korschgen 1971; Legler 1977; Parmenter and Avery 1990). We used the nondestructive technique of fecal analysis to examine the dietary preference of an estuarine turtle, the diamondback terrapin *(Malaclemys terrapin)*. As the animals belonged to a demographic study of wild terrapins, there were concerns about preventing losses to the population. Fecal analysis was chosen as the preferred analytic technique because it is less invasive than stomach-pumping and does not involve sacrificing individuals from the population. We were able to address a disadvantage of this method indicated by Folkerts (1968) who noted that prey items that leave no trace in the feces are overlooked, meaningful volumetric analysis is precluded, and fecal remains often are difficult to identify. Concerned with these drawbacks, we developed an efficient method to separate fecal material, found that fecal remains from *Malaclemys* could be easily identified and prey size distribution quantified.

The diamondback terrapin is the only North American emydid of widespread occurrence in saltmarshes (Carr 1952; Ernst and Barbour 1989). Although terrapins principally feed on marsh-dwelling snails and crabs (Carr 1952), their functional role as macro-consumers has been largely overlooked for temperate salt marsh ecosystems (Pomeroy and Wiegert 1981). All studies of terrapin diet (reviewed by Palmer and Cordes 1988) concluded that the most important dietary item was snails. However, no studies to date have examined the size distribution of food items ingested by wild terrapins. To investigate the food habits of terrapins, we used a winnowing device to separate fecal samples into components based on similar mass.

Our study was part of an investigation to define the ecology of terrapins near a South Carolina barrier island (Lovich and Gibbons 1990; Lovich et al. 1991). From the intertidal saltmarsh west of Kiawah Island, we collected 294 terrapins using trammel nets and seines from 22 June to 27 July 1991. Fecal samples were collected for 21–48 h post-capture during temporary confinement in fiberglass holding bins (80 x 45 x 45 cm). Fecal materials were washed into U.S. Standard Testing sieves (#18 = 1 mm) and air dried for 24-48 h.

The samples consisted of snail shell fragments *(Littorina irrorata)*, intact snail opercula *(L. irrorata)*, and fragments of crab exoskeleton *(Uca* spp., *Calinectes sapidus*, *Sesarma* spp.). *Littorina* was both numerically and volumetrically (minimum estimate of 90%) the most significant prey item. A linear regression of opercula length (x) to snail length (y) was generated from measurements spanning all size classes of *Littorina* in the area ($y = 2.9 x - 1.1$, $r^2 = 0.90$, $n = 270$, $p = 0.001$). The positive relationship allowed us to reconstruct the size range of snails ingested from intact opercula in the fecal sample. However, the analysis was impeded by the difficulty of sorting out the small snail opercula (2-8 mm diam).

We constructed a winnowing apparatus to facilitate the separation of opercula from the heavier portions of the sample (crab legs, shell fragments, sediment) (Fig. 1). Dried fecal material was carefully loosened from the bottom of the sieve (S) and a large inverted funnel (F) was fitted closely over the upper rim of the sieve to cap it, forming the lower chamber. The funnel's spout was directed upwards with a nylon mesh (M) surrounding the spout. The spout was inserted through a 3 cm slit incised in the bottom of a mesh jelly strainer and secured with a rubber band [RB]). An inverted 500 ml beaker (B) was held a short distance above the funnel spout. The nylon mesh was secured around the lip of the beaker with another rubber band. A stream of air provided by a small hair dryer (HD) was directed upwards through the sieve. A support for this device can be made from 1/4" plywood, threaded rod, and nuts to lend stability for one individual to winnow a sample unassisted.

The principle of winnowing is to separate items by their relative mass. To operate the winnowing device, the air jet is aimed at the bottom of the sieve to suspend or propel fecal particles of different mass. Lighter particles suspended by the air jet are directed through the funnel into the upper chamber while heavier particles remain in the lower chamber. Particles in the upper chamber are deflected downwards after hitting the beaker and accumulate in the nylon mesh surrounding the funnel spout. By changing the distance of the beaker above the funnel, the capture efficiency of the upper chamber is varied. When the sample has been winnowed sufficiently to separate particles of similar mass, the sieve is removed and the upper chamber is inverted. The particles

contained by the mesh are carefully shaken into the beaker. Distinct sequential separations by mass are achieved by progressively moving the air source closer to the sieve. The time necessary to separate a sample declines from about 1 h for manual sorting to < 5 min when winnowing.

This apparatus is useful in dietary studies of animals that leave recognizable fecal remains as evidence of dietary preference. The analysis is ideally suited to dietary specialists that concentrate upon molluscs or gastropods, e.g., *Graptemys, Kinosternon, Macroclemys, Malaclemys, Malayemys,* and adult *Sternotherus* are all noted to feed extensively upon snails (Ernst and Barbour 1989; Folkerts 1968). Ingestion of plant tissue or soft foods by chelonians might be underestimated by the technique since this material is not easily identified.

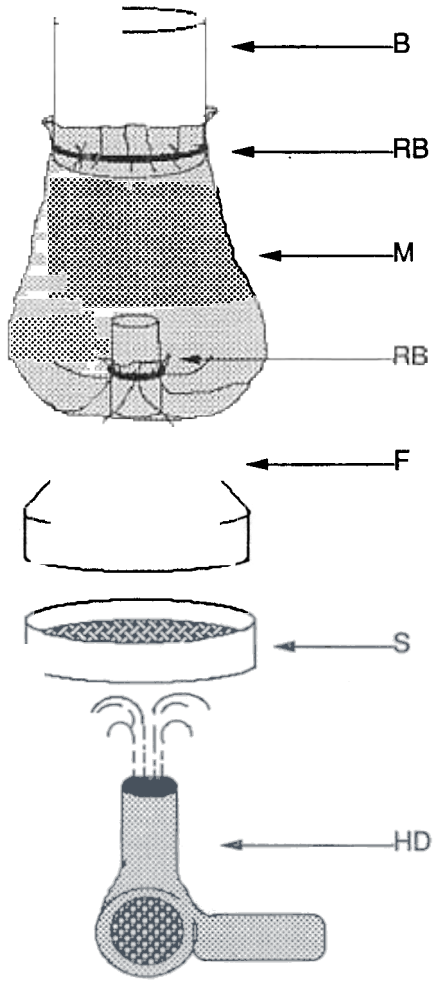

FIG. 1. A winnowing apparatus for separation of dietary components from fecal samples of mollusc-feeding turtles. Components include: beaker (B), fine mesh (M), rubber bands (RB), a funnel (F), a #18 mesh sieve (S), and a hair-dryer (HD).

The method may also provide an approach to investigate size-related resource partitioning, particularly in sexually dimorphic species such as *Graptemys barbouri, Graptemys pulchra,* and *Malaclemys terrapin* (Ernst and Barbour 1989; Gibbons and Lovich 1990; Vogt 1981). In those species, resource partitioning may serve as a driving force in the evolution of sexual dimorphism (Camilleri and Shine 1990; Shine 1989) to reduce intraspecific competition. If a relationship exists between body size and food size selectivity (Schoener 1974), it may be overlooked if dietary components are analyzed solely on a volumetric or numerical basis rather than a size specific basis. With the aid of a winnowing apparatus data will better indicate the extent of niche overlap, either between sexes and size classes or interspecifically, if multiple species are being compared. The technique is particularly useful to estimate the magnitude and selectivity of predation by snail-feeding specialists.

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