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A MODIFIED THROW-TRAP TO SAMPLE PREY FOR WADING BIRD STUDIES

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Abstract.—We studied the foraging ecology of wading birds in shallow-water mangrove swamps in southwestern Puerto Rico in 1994–1995. We needed reliable estimates of prey availability. Kushlan's (1981) 1-m^2 throw-trap is useful to obtain such estimates in various shallow-water habitats. However, its heavy, box-like frame made it difficult to work in our study area. Here, we describe a modification to and use of the throw-trap, evaluate its performance, and give an example of its application to wading bird foraging studies. The modified trap retained its basic sampling unit (i.e., 1-m^2), but was lighter, easy to use, and suitable for sampling prey in areas of uneven bottom contours in a standardized fashion. We found that the correlation between estimates of prey abundance and number of successful foraging attempts by focal wading birds was significant (Spearman Rho = 0.34, $P < 0.001$), suggesting that data provided an estimate of prey availability. Thus, data collected with the modified trap were suitable to test whether patterns of prey availability influenced wading bird distribution. We found that the mean number of prey/m^2 in used sites (i.e., $\geq$ two foraging birds) (131.28 $\pm$ 16.53[SD]) was significantly higher than random sites (26.28 $\pm$ 6.66). Significant differences were also true when tests were conducted by individual prey items like *Poecilia* and *Xiphocaris*, important in the diet of wading birds in our study area.

UNA TRAMPA DE TIRO MODIFICADA PARA EVALUAR LA ABUNDANCIA DE PRESAS PARA ESTUDIOS DE AVES VADEADORAS

Sinopsis.—Estudiamos la ecología de alimentación de aves vadeadoras en aguas llanas de manglares en el suroeste de Puerto Rico durante 1994 y 1995. Para ello precisamos de estimados de disponibilidad de presas. La trampa de tiro de Kushlan (1981) es útil para obtener dichos estimados en varios tipos de hábitats de aguas llanas. Sin embargo, su pesado y rigido armazón hizo difícil su uso en nuestra área de estudio. En este trabajo describimos una modificación a la trampa, su uso, evaluamos sus atributos y damos un ejemplo de su aplicación en estudios de aves vadeadoras. El arte modificada retiene la unidad básica de muestreo (i.e., 1-m^2). Sin embargo, es más ligera, fácil de usar y adecuada para muestrear presas en forma estandarizada en hábitas de poca profundidad y de fondos irregulares. Encontramos que la correlación entre estimados de abundancia de presas e intentos de alimentación exitosos por ave fue significativa (Spearman Rho = 0.34, $P < 0.001$), sugiriendo que los datos proveen una medida de disponibilidad de presas. Por lo tanto, datos obtenidos con el arte modificada son adecuados para poner a prueba si patrones de disponibilidad de presas influencian la distribución de aves. Encontramos que el número promedio de presas/m^2 en áreas usadas ($\geq$ dos aves alimetándose) (131.28 $\pm$ 16.53[SD]) fue significativamente más alto que en áreas aleatorias (26.28 $\pm$ 6.66). Diferencias significativas también se encontraron por tipo de presas como *Poecilia* y *Xiphocaris*, presas importantes en la dieta de las aves en nuestra área de estudio.

Shallow-water wetlands constitute important foraging habitats for wading birds (Ardeidae) (Kushlan 1978, Ramo and Busto 1993). Studies aimed at gaining a better understanding of their resource use require reliable estimates of prey availability (Draulans 1987, Kushlan et al. 1985, Miranda 1995, Ramo and Busto 1993). In studies such as those focusing on functional responses, prey needs to be sampled repeatedly, prohibiting the use of non-replacement or lethal sampling options (e.g., toxicants) that could affect results (Davies and Shelton 1989). Sampling shallow-water habitats, however, is often constrained by the size and weight of the sampling gear, the set-up time, and the number of persons required to operate the gear (Hayes 1989, Hubert 1989, Kjelson et al. 1975). Different bottom conditions (e.g., roots, debris) might also preclude the use of the same sampling gear, which limits statistical treatment of data and comparison of results.

Estimates of prey density in shallow-water habitats can be obtained using portable, open-bottom nets that surround a fixed area of the water surface (Davies and Shelton 1989, Kushlan 1981). Kushlan (1981) reported the sampling characteristics of three different traps and concluded that a 1-m^2 throw-trap was the most precise. Although biases were detected in all traps (up to 31%), the ability to replicate sampling efforts with a portable, fixed-area sampling unit provides an opportunity to standardize sampling protocols within and across treatments of interest and maximize precision. Kushlan's (1981) throw-trap design was used successfully to study foraging behavior of wading birds in tropical wet savannas (Kushlan et al. 1985), and shallow marine environments (Kushlan 1981). We studied the foraging ecology of wading birds in shallow-water mangrove habitats in southwestern Puerto Rico from 1992–1994 (Miranda 1995). For our needs, however, Kushlan's (1981) trap design presented two limitations. First, the trap's box-like design, with its heavy pipe frame, made walking through the mangrove swamps a difficult task (a heavy frame ensures that the trap will sink quickly to capture prey). Second, Kushlan's throw-trap did not block prey effectively in our study area. The trap often landed on top of snags and roots, letting prey escape through the bottom of the trap. Here, we describe modifications made to the original trap design to overcome these limitations, explain how the trap is used, evaluate its performance, and give an example of its application to wading bird studies.

STUDY AREA

Field work was conducted in 1992–1994 at the Boquerón Wildlife Refuge located in southwestern Puerto Rico, east of Boquerón Bay, Cabo Rojo (18°00'N, 67°08'W). The refuge is comprised of shallow-water lagoons bordered by Red (*Rhizophora mangle*), Black (*Avicenia germinans*), and White (*Laguncularia racemosa*) mangroves. Data were collected in the southwestern portion of the refuge. The area consists of 83 ha of mangrove forest bounded on the east and west by dikes. Thirty percent of the area is open water with an average depth of 11 cm (maximum =

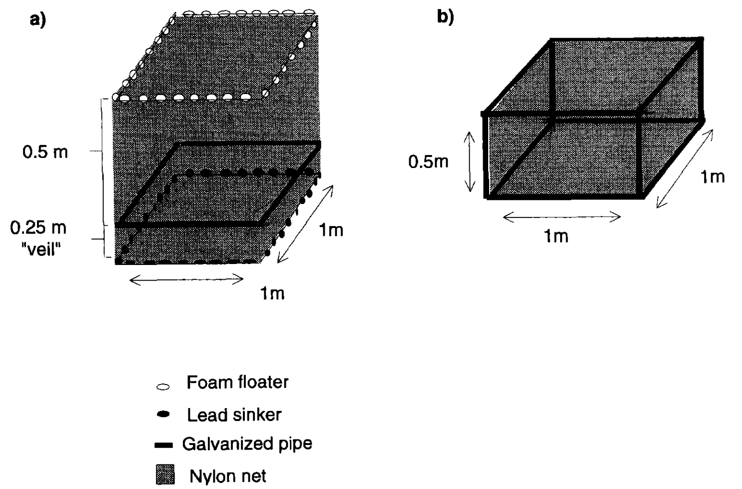

FIGURE 1. Diagram of the modified throw-trap (a) and of Kushlan's (1981) design (b).

25 cm). Wading birds foraged in open water pools that ranged between 5–510 m^2 in size (mean = 292 m^2). These pools had muddy bottoms and often scattered underwater snags, stumps, and roots.

TRAP MODIFICATION AND USE

We overcame Kushlan's (1981) design limitations by eliminating most of the frame from the original design except for the bottom pipes, which delineates the 1-m^2 sampling unit. We attached a 50-cm long, 3.2-mm mesh size nylon net, opened on the top and bottom to one side of the 1-m^2 frame (Fig. 1a). This net was fitted with 40 foam floaters, which create a square enclosure when thrown in the water. To the other side of the frame, we attached 25-cm long nylon net, of the same mesh size, extending or hanging from the frame forming a "veil." This veil was flexible and capable of blocking fish irrespective of most bottom contours. Blockage was aided by 28 lead sinkers of 28.35 g each attached to the veil's edge (Fig. 1a). Modifications did not alter Kushlan's basic design (i.e., 1 $m^2 \times 0.5$ m, Fig. 1b), but the resultant trap was lighter and easier to use, enabling one person to handle the whole sampling process, and suitable for shallow-water habitats of varying bottom characteristics.

The trap should be thrown as horizontally as possible, so that when it hits the water it is almost parallel to its surface. We had no problem throwing the trap in such a fashion distances up to 6 m. Once in the water, the veil should be quickly pushed into the bottom substrate to block (secure) any possible gaps. We removed prey using a 30 cm (1-mm mesh) dip-net after stretching the sides of the trap. Dip-netting was stopped following three empty sweeps in a row, after which we assumed that all prey had been removed.

PERFORMANCE AND APPLICATION

We used the throw-trap to obtain an index of prey availability, and to relate prey numbers to wading bird distribution (e.g., used vs. randomly selected or non-used sites). To address these needs, prey was sampled at a total of 88 sampling sites. Of these, 39 were used sites (i.e., ≥ two foraging birds) and the remaining were selected randomly. Two to six throw-net samples were taken from each sampling site, depending on its size. In these throw-net samples we identified sixteen species of fish representing seven families, including larval stages of tarpon (*Megalops atlanticus*). The average size of captured fish was 38.31 ± 1.08 mm; the range was 10–130 mm (n = 220). Also, we identified one species of shrimp, *Xiphocaris elongata*. Species composition and size obtained from our sampling efforts was similar to that reported by Miller and Collazo (1994) in the same study area and time, but using different sampling methods (e.g., seine, rotenone). The average size of fish in stomachs of wading birds was 41.5 ± 9.2 mm, ranging from 16.5–109.5 mm (n = 240), matching closely the range of fish sizes sampled with the throw-trap (Miranda 1995). Furthermore, we found a positive and significant correlation between mean number of successful foraging attempts (based on 5-min focal observations) and prey abundance at the site (Spearman Rho = 0.33, P = 0.0001), suggesting that the modified throw-trap yielded a relevant measure of prey availability (see Hutto 1990). Indeed, total prey densities in used sites (131.28 ± 16.53[SD], n = 39) were significantly higher than in random sites (26.28 ± 6.66, n = 49) ($t = -8.03$, df = 86, $P < 0.001$). The same was true when densities of guppies (*Poecilia*) (85.59 ± 15.10 vs. 18.59 ± 4.97) and *Xiphocaris* (23.85 ± 6.00 vs. 4.75 ± 1.12) were examined separately, primary constituents of the diet of wading birds in our study area (Miranda 1995).

Wading birds distributed themselves in areas of higher prey density as indicated by the modified throw-trap. The power of the tests comparing square-root transformed prey data from used and random sites was 1.0, indicating that at our sites the modified trap gave sufficient precision not to compromise power of statistical tests. At an alpha level of 0.05 and the variability of our transformed data, the minimum number of samples required to detect differences between both types of sites would be 8.09, and tests would be able to detect differences in mean number of prey between sites of 1.66/m^2 (i.e., sensitivity of test) (JMP 1994). The power of the test was also very high for *Poecilia* and *Xiphocaris* (i.e., 0.99). Tests indicated that, given our variability, fewer samples could have been taken to detect significant differences between used and random sites.

Our modification of Kushlan's (1981) throw-trap did not alter its basic design (1-m^2 sampling unit), but made it easier to carry and handle in the field, and sample areas of uneven bottom contours as those found in shallow water mangrove habitats. The modified trap was a useful sampling technique to determine relative prey abundance as it provided a means to replicate sampling efforts throughout the study area (i.e., standardization). Modifications to Kushlan's (1981) trap design successfully sampled wading bird's prey availability, at least for the prey assemblage present in the water column (i.e., nekton). The trap is not designed to sample prey that may burrow (e.g., crabs) or embedded (i.e., benthos). Estimates of prey density were useful to test hypotheses regarding foraging site selection of wading birds.

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